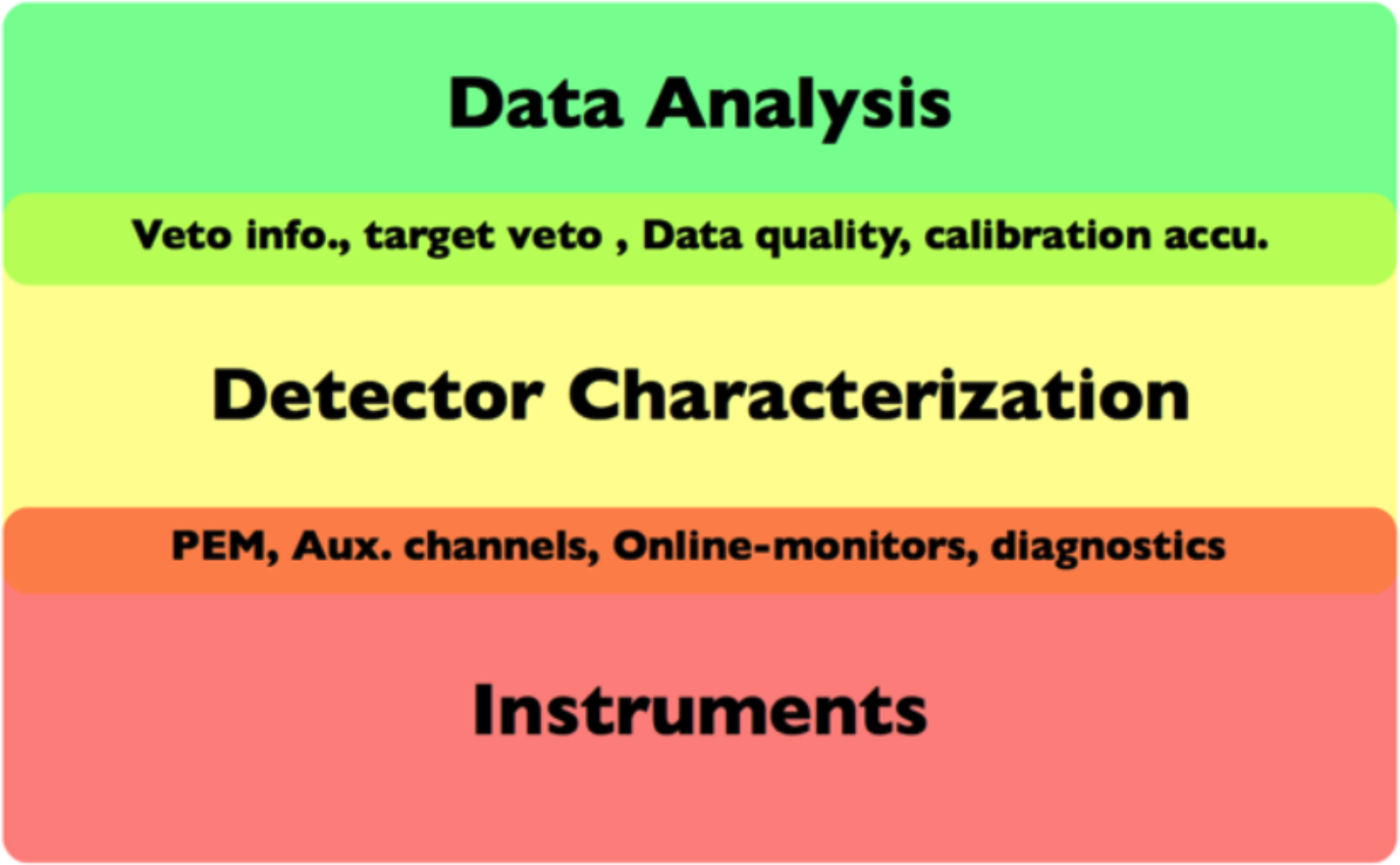
Status of KAGRA detector characterization

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

- Detector Diagnostics
  - Supports of subsystems
  - Help noise hunting
  - Development of characterization tools
  - Daily summary monitor
  - Monitoring Environment around KAGRA

For Data analysis side

- Data quality information
- Veto analysis with DAS

iKAGRA run

Tools running during iKAGRA

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

H.Yuzurihara+ PRD (2016)

- Realtime Quick look webpage

User Interface

- 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

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	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
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	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Apr. 2016

Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Su
				1	2	
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Mar. 2016

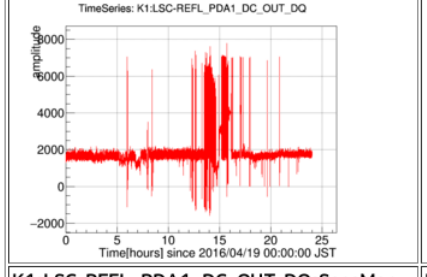
Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Su
	1	2	3	4	5	
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Feb. 2016

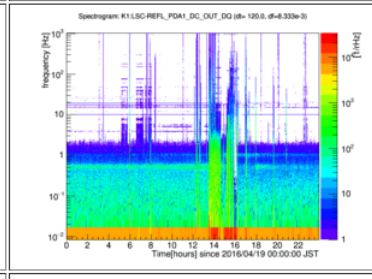
Local Date:
2016-04-19
Layout:
- Channel Order
- Monitor Order

K1:LSC-REFL_PDA1_DC_OUT_DQ

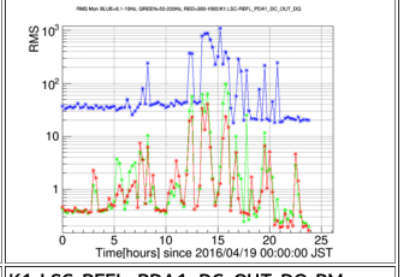
K1:LSC-REFL_PDA1_DC_OUT_DQ:TimeSeries



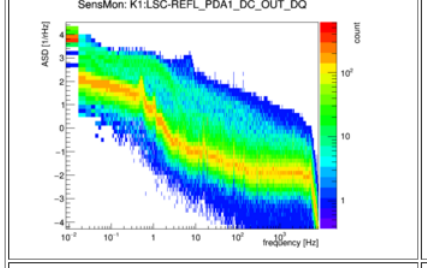
K1:LSC-REFL_PDA1_DC_OUT_DQ:Spectrogram



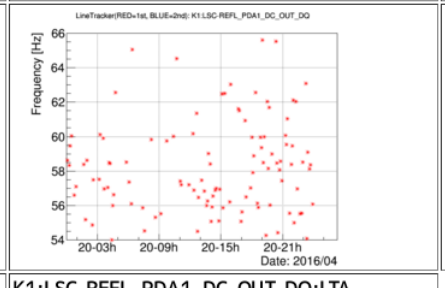
K1:LSC-REFL_PDA1_DC_OUT_DQ:RMSMon



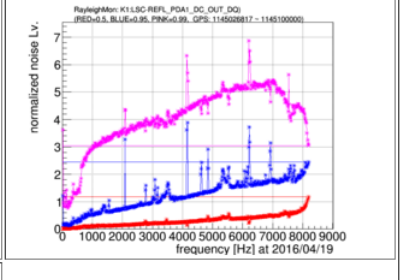
K1:LSC-REFL_PDA1_DC_OUT_DQ:SensMon



K1:LSC-REFL_PDA1_DC_OUT_DQ:LTF

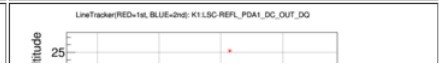


K1:LSC-REFL_PDA1_DC_OUT_DQ:RMon



K1:LSC-REFL_PDA1_DC_OUT_DQ:SRMon

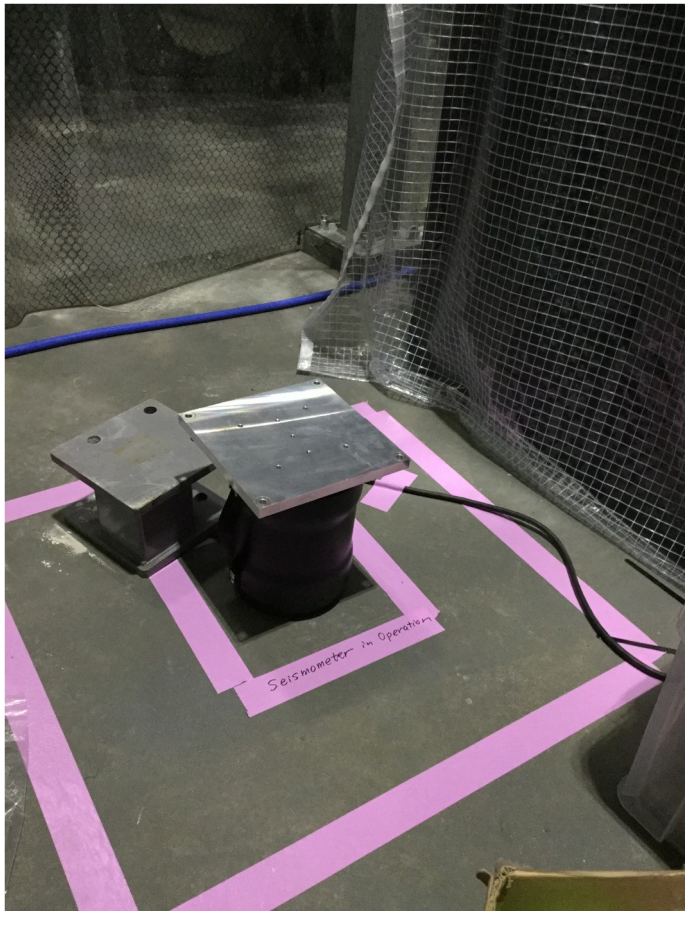
K1:LSC-REFL_PDA1_DC_OUT_DQ:LTA

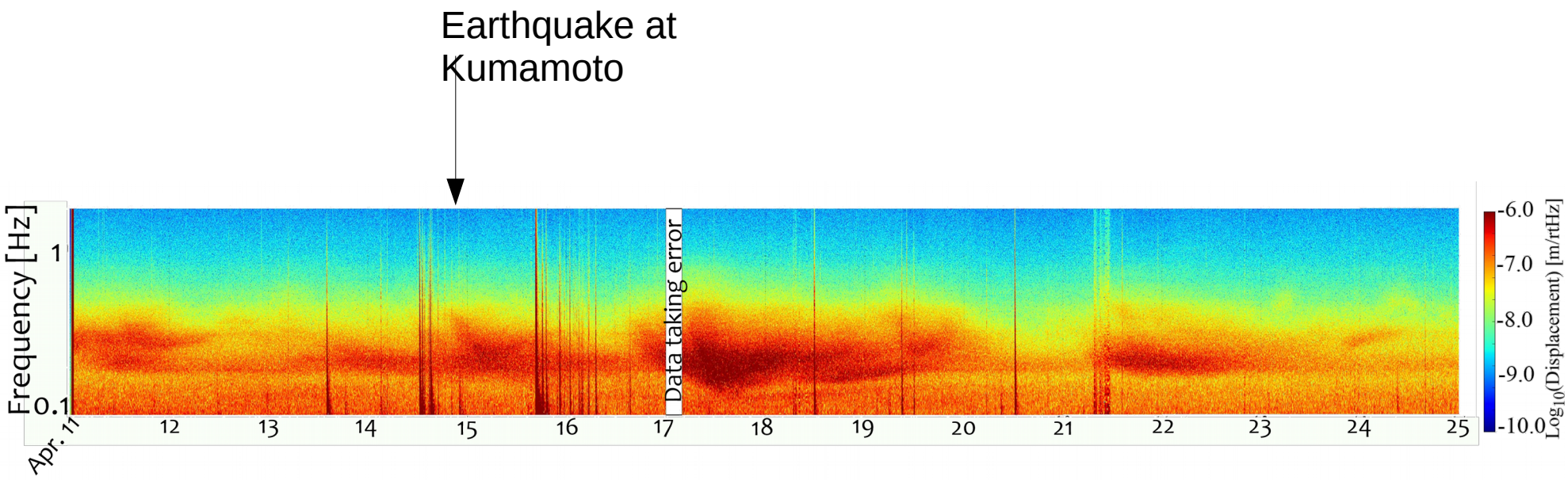


- **Monitored 43 channels (almost 50 channels)**
- **Daily Summary Page was basically running correctly, but failed for several days.**
  - **In case some data is not normal (NAN), this can happen**
- **Computation time growin**
- **Poor documentation.**
- **Need some bootcamp**

Environmental Monitors in iKAGRA

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



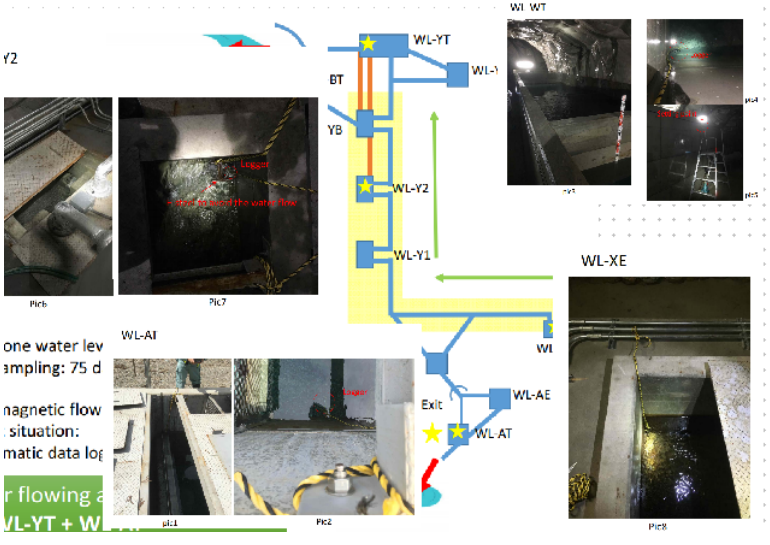

Earthquake at
Kumamoto
Frequency [Hz]
1
0.1
Data taking error
Apr. 11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
-6.0
-7.0
-8.0
-9.0
-10.0
Log10(Displacement) [m/rtHz]

A. Shoda (NAOJ)

Start water monitoring

Shikano-san's talk

- **Right before the 2nd iKAGRA test run, we started monitoring water level.**
- **The water monitoring is continuing.**

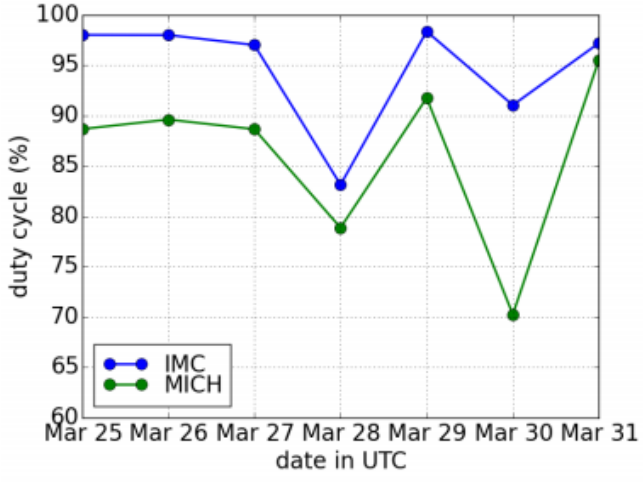


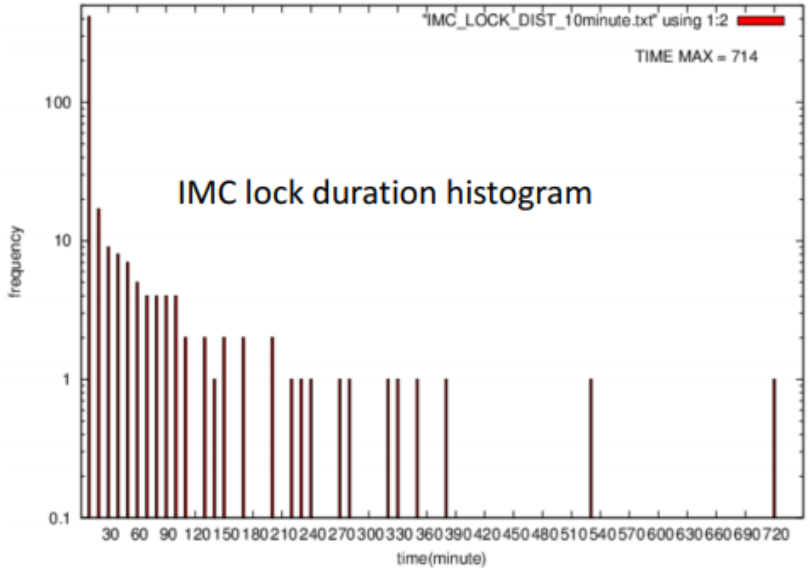
Duty Cycle(Mar.25-Mar.31,2016)

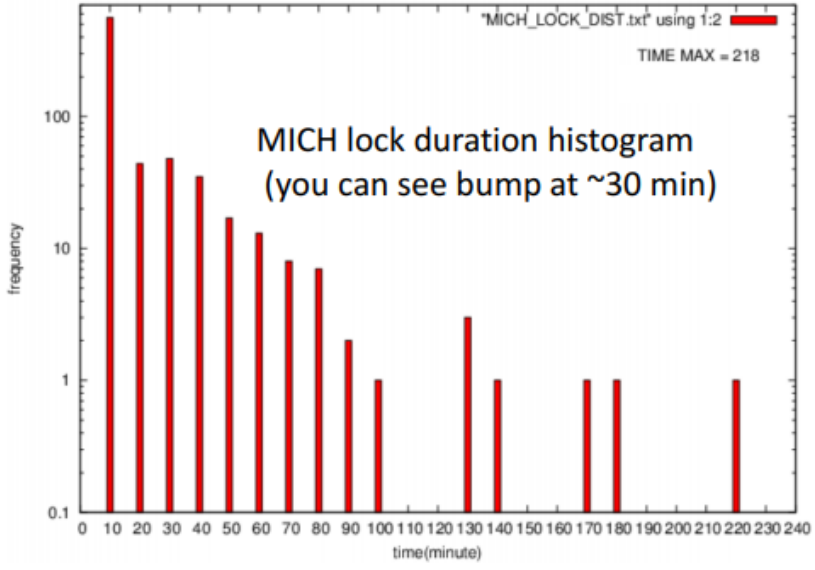
- **Duty factor: 85.2 %**
  (94.4 % for IMC)

data processing and plot by Y. Sasaki

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

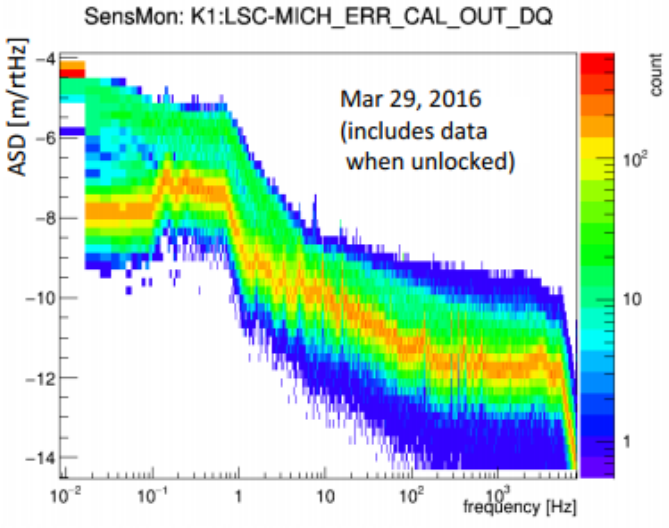


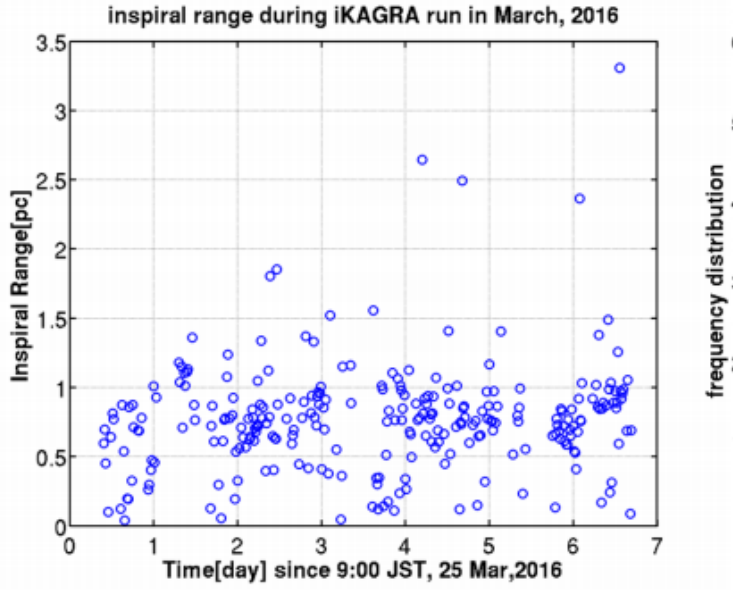


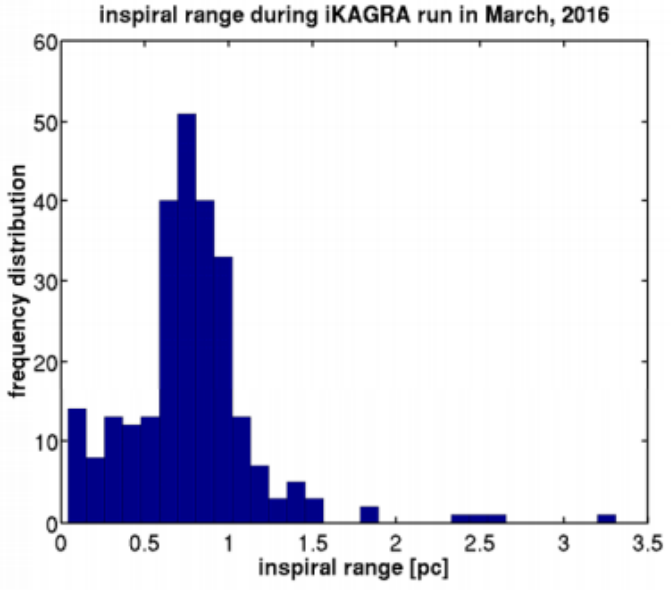


Inspiral Range

- 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



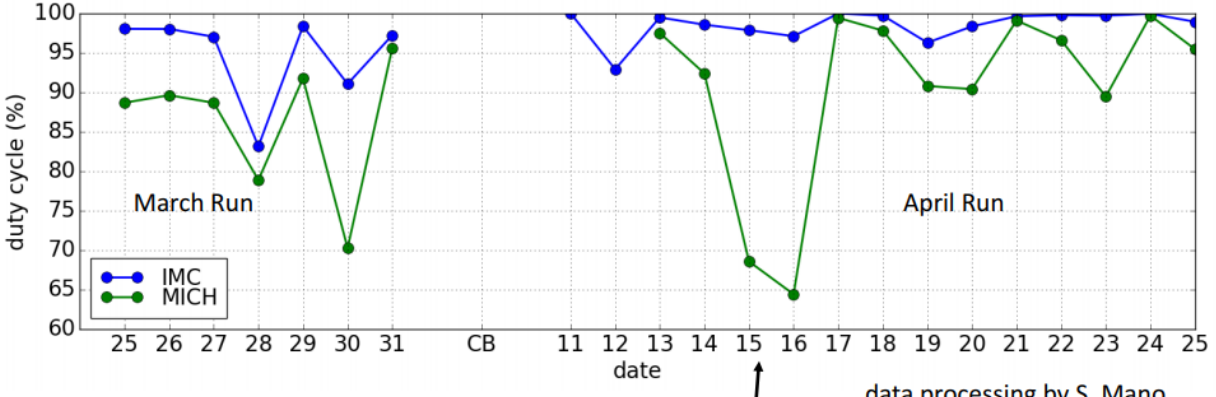




plot by K. Hayama

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.

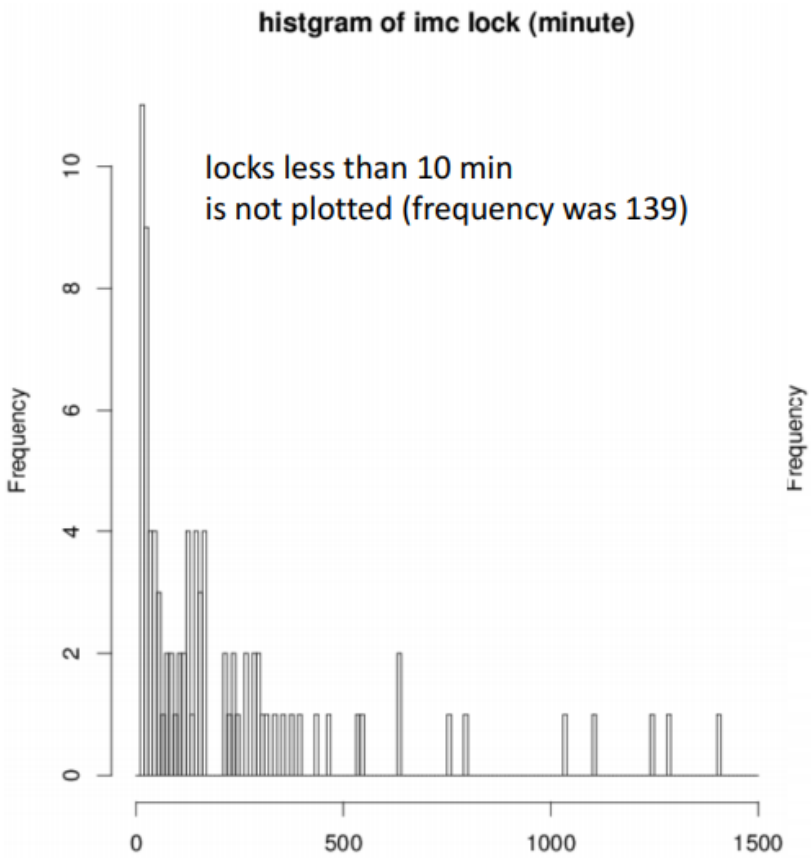
Kumamoto Earthquake, BS went wrong

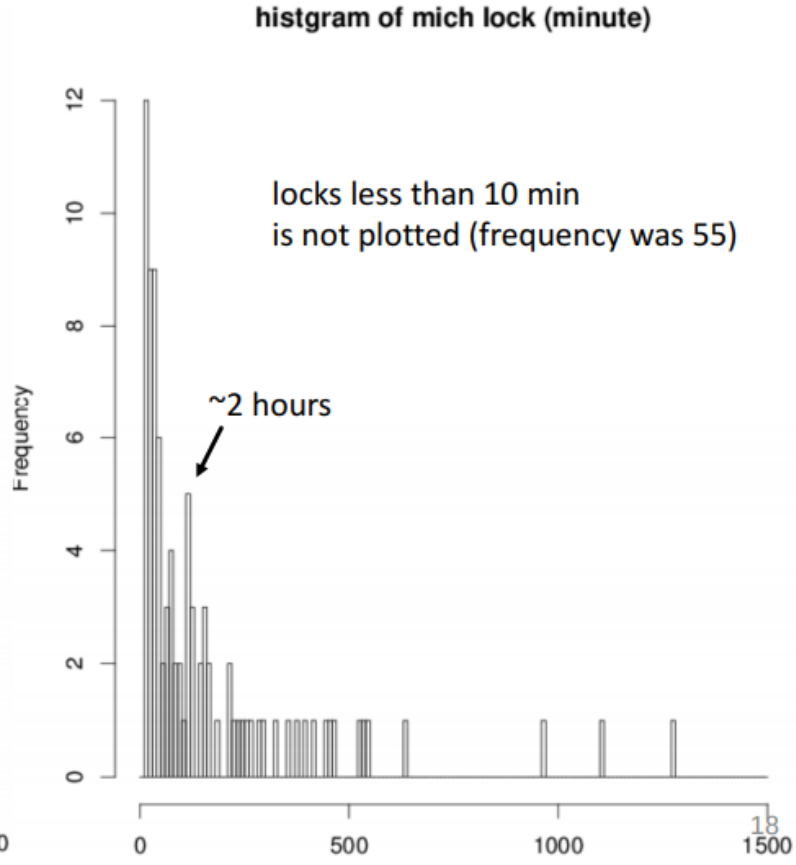
data processing by S. Mano
plot by Y. Michimura

Lock Duration(April11-April25)

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

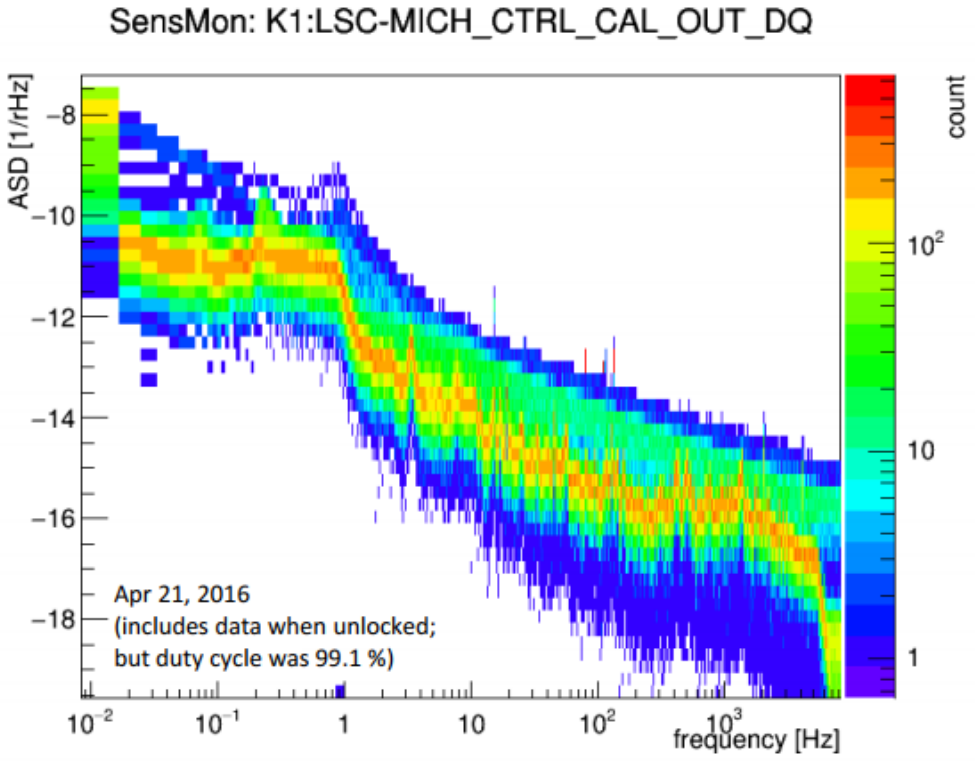
data processing and plot by S. Mano





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**

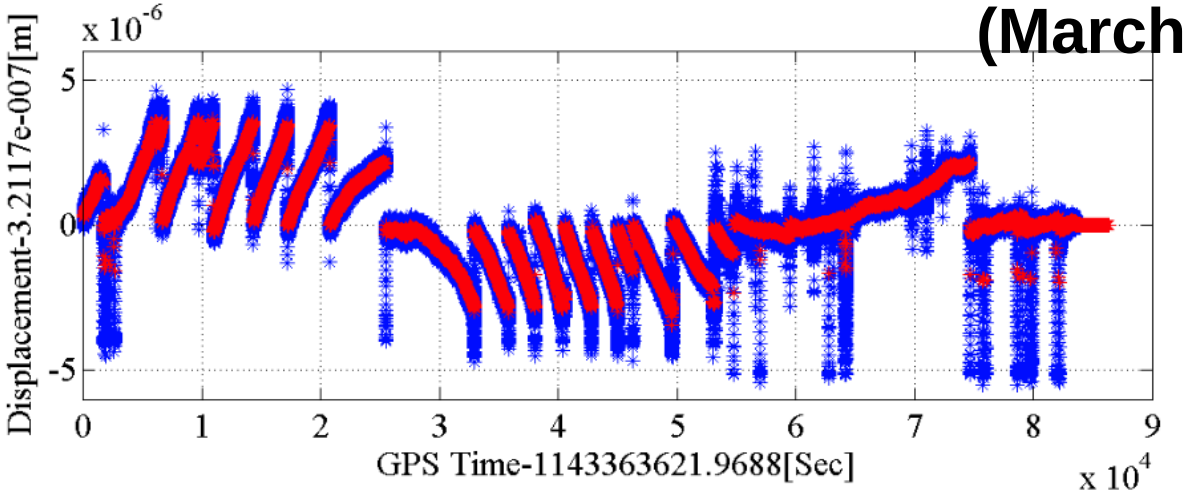


plot by K. Hayama

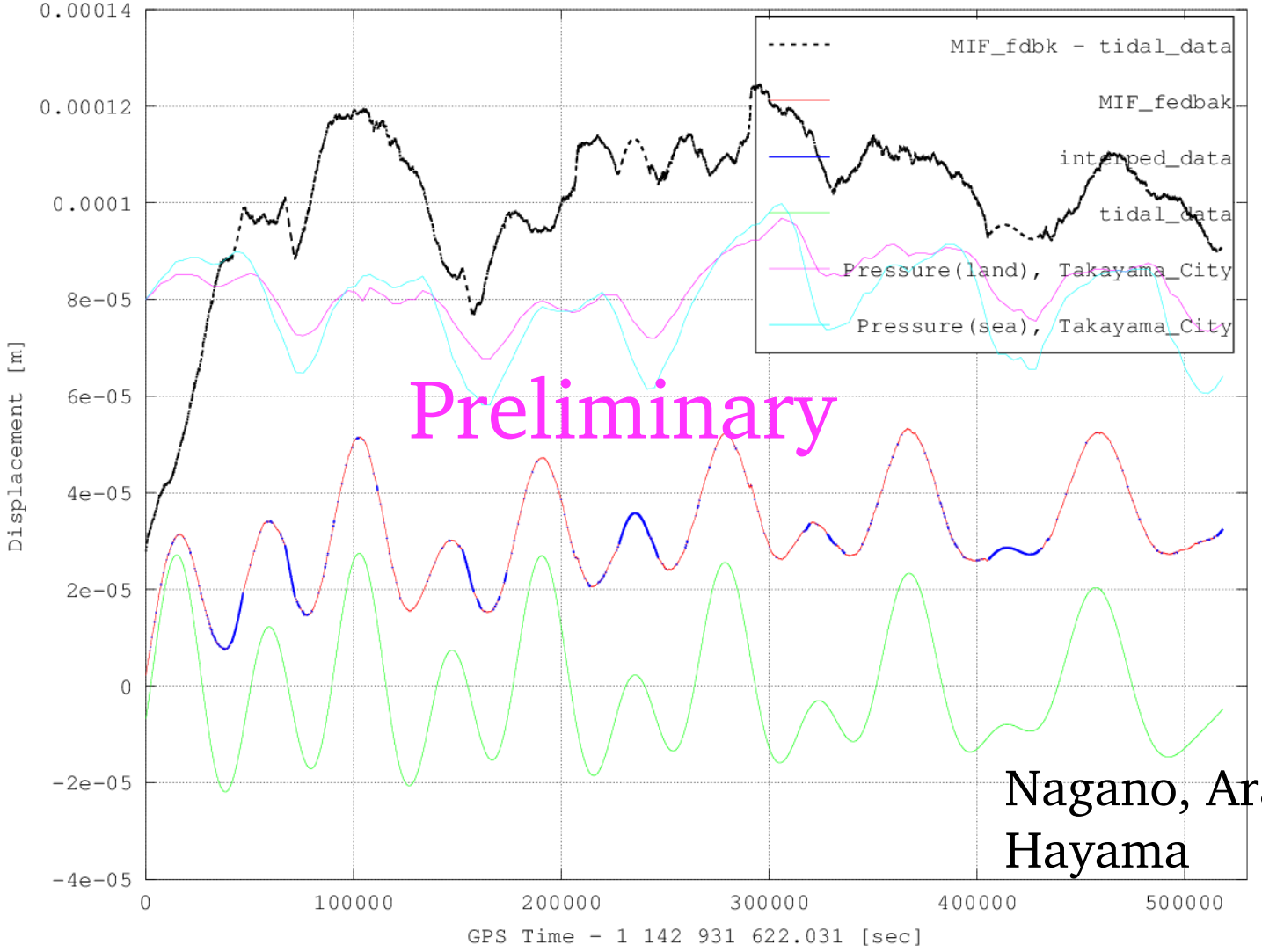
Differential of the X and Y arms

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

1day plot (March30-31)

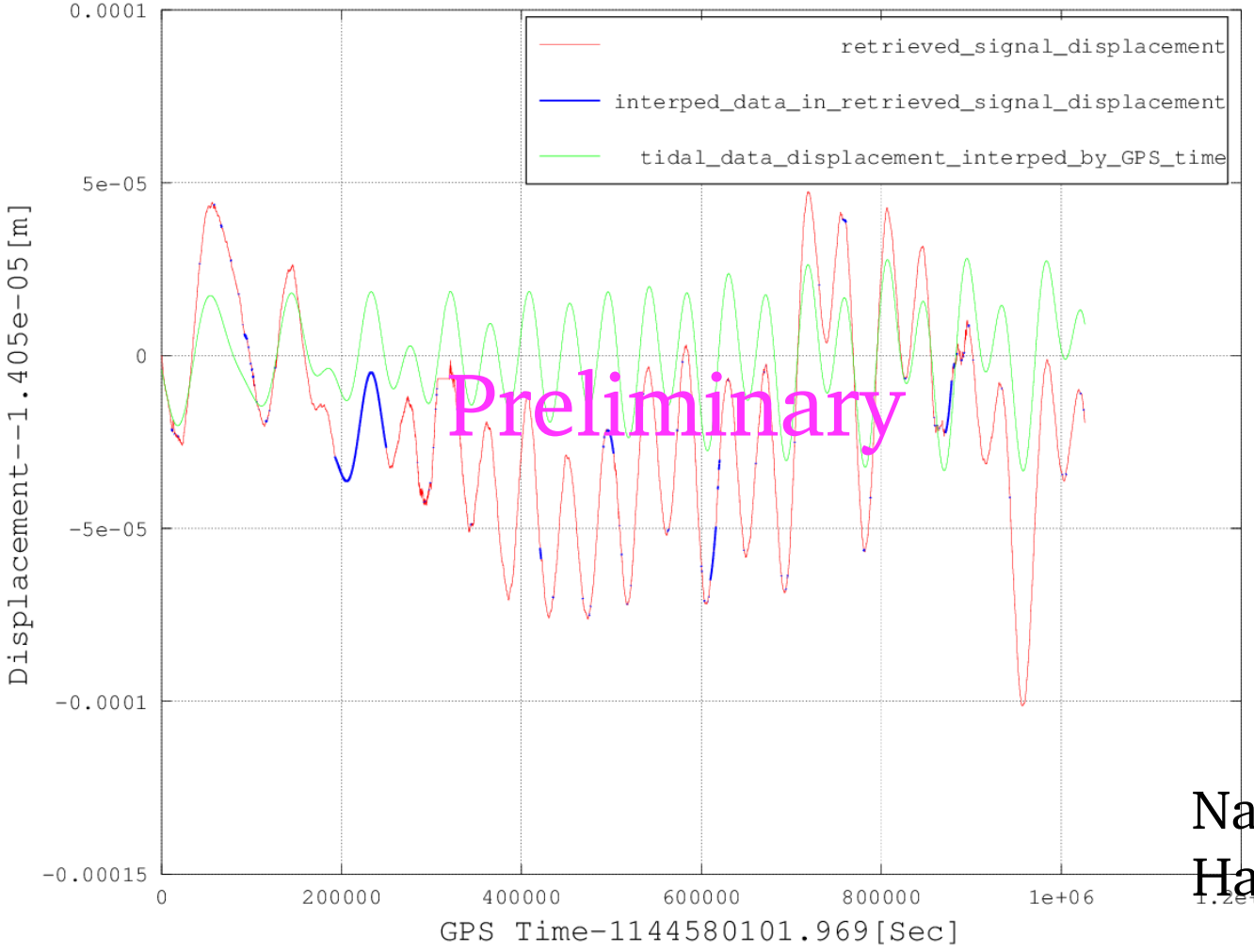


Tidal Distortion(Mar.25-Mar.31)



Nagano, Araya, Hayama

Tidal Distortion(April11-April25)



Nagano, Araya, Hayama

Veto Analysis

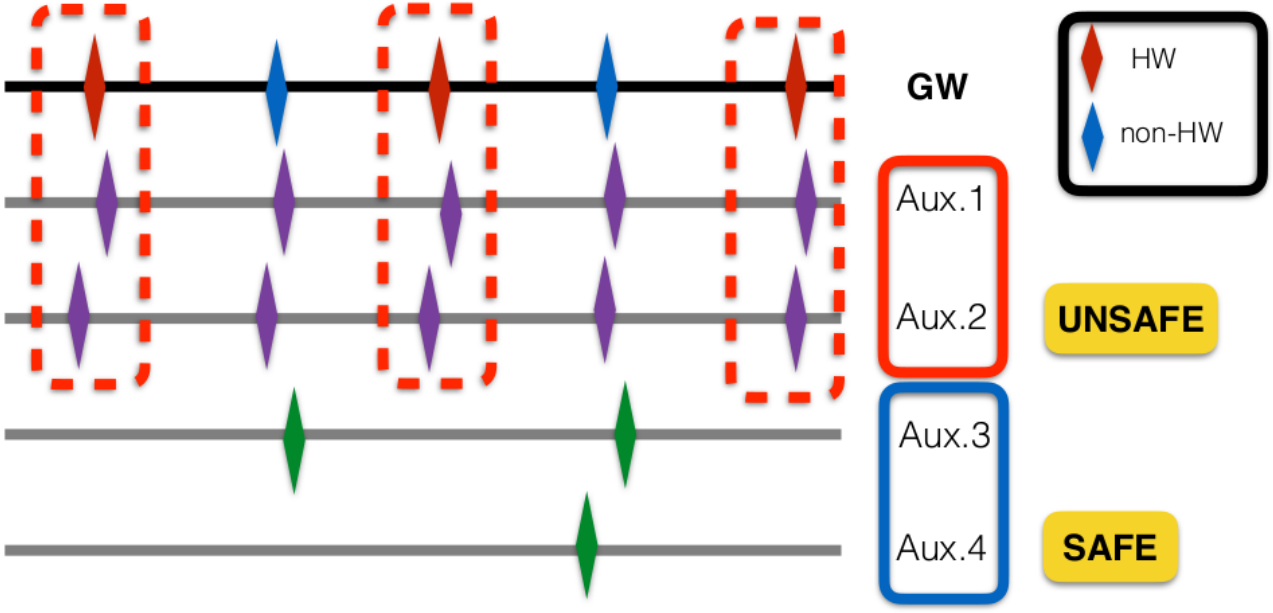
KGWG detchar

- Using multi-channel information
  - Safe channel study
  - Correlation analysis between GW channel and Aux channels

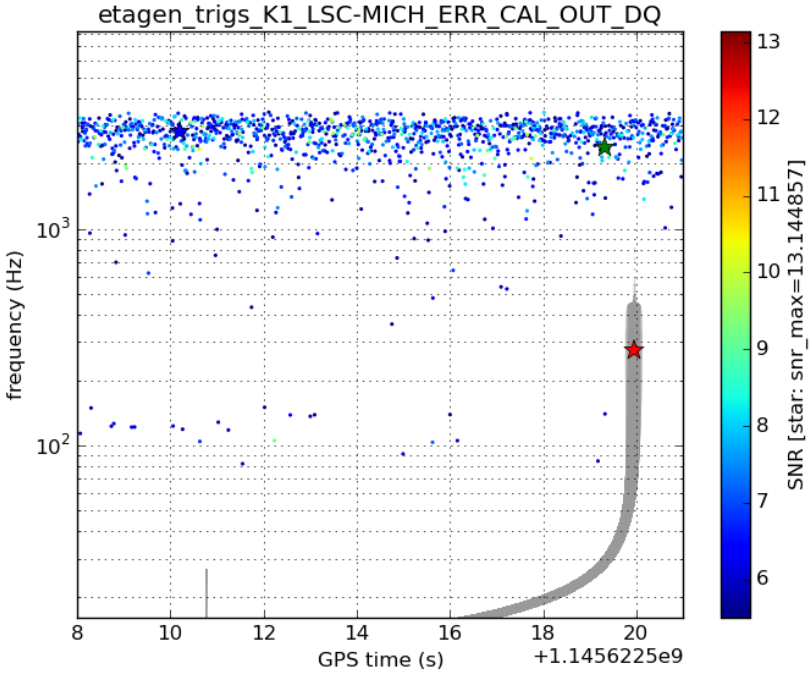
Safe Channel Study

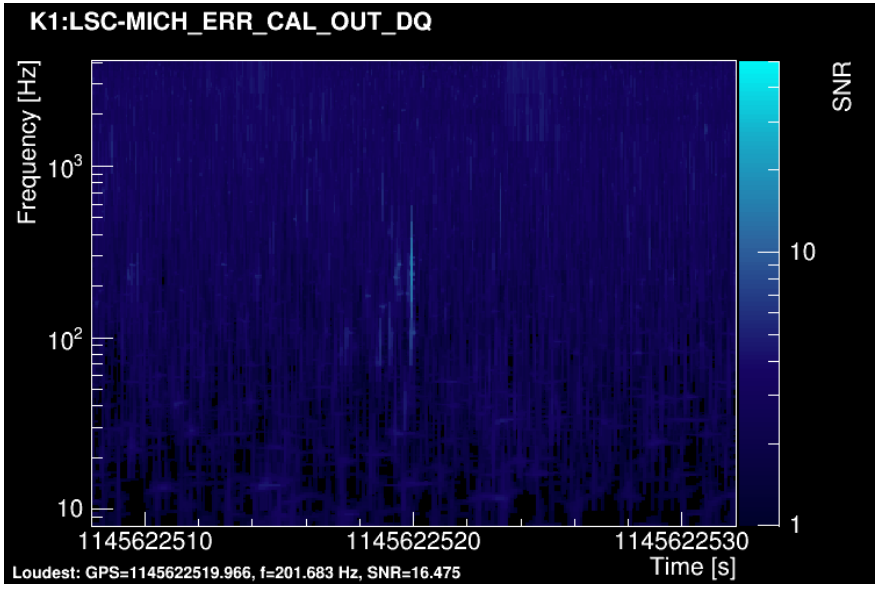
Young-Min Kim (SNU)

- 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).



Multiple Glitch Detection

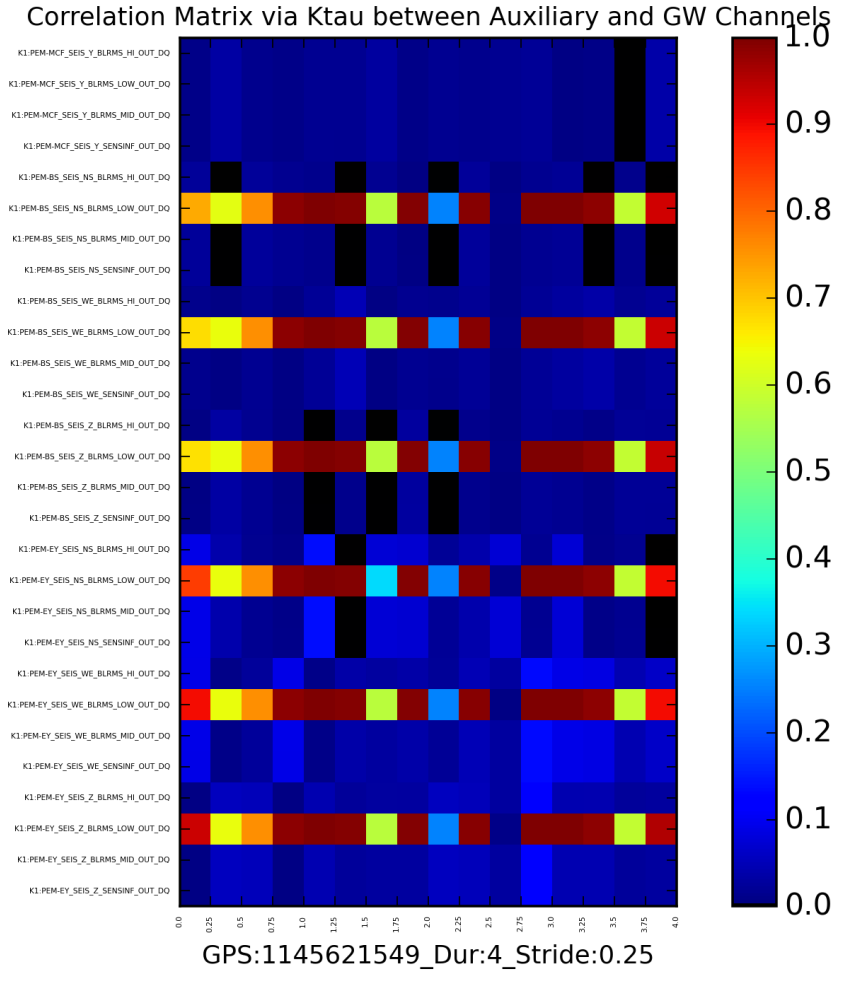




http://seikai.icrr.u-tokyo.ac.jp/~eddy/etagen-1145622508-13.html

Correlation analysis between GW and PEM

J. Oh ++



Schedule (Data Characterization)

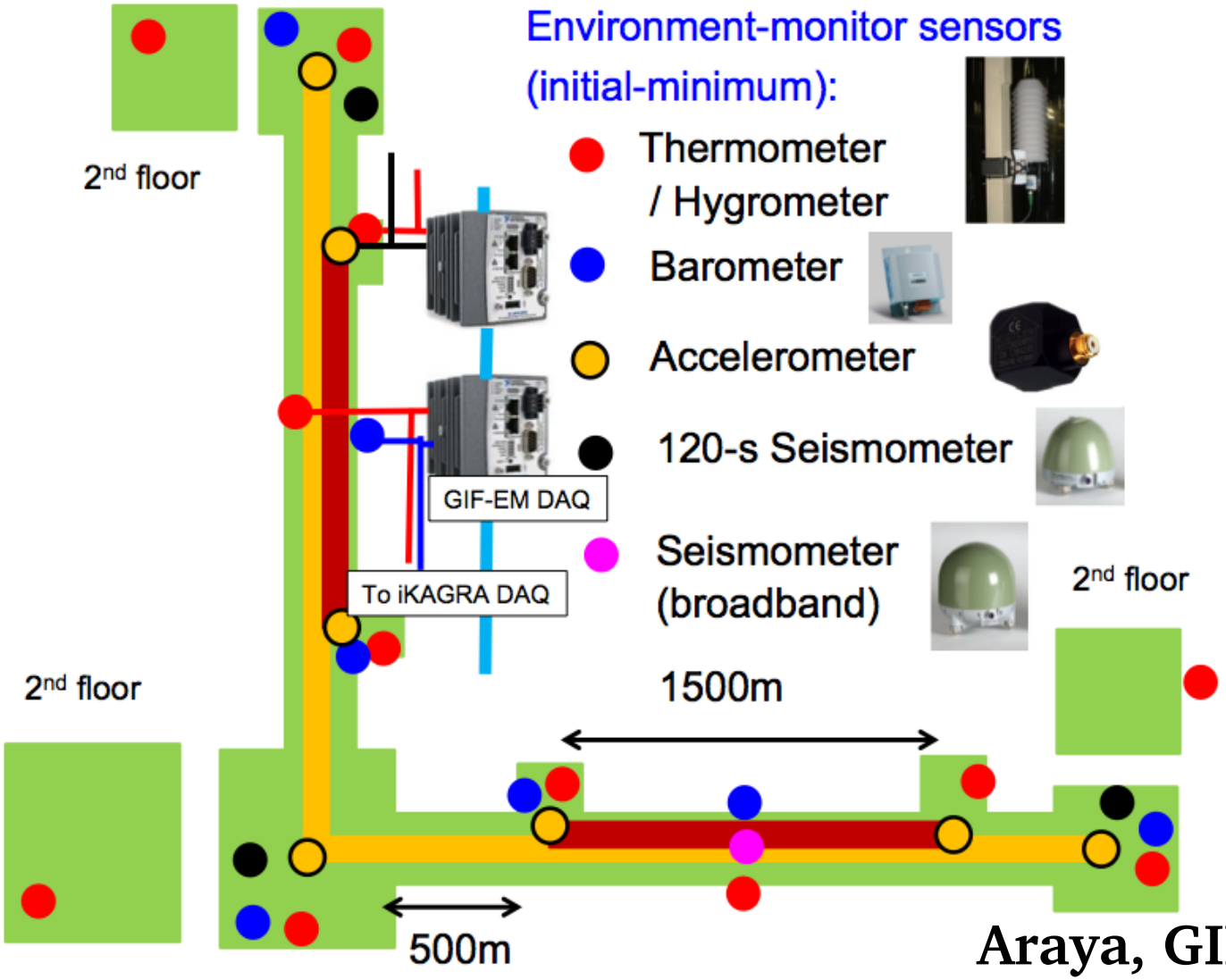
- IKAGRA (in 2016)
  - Stationarity evaluation
  - Trend of x-y
  - Gaussianity
  - Lock loss study
    - IMC and
  - Multichannel correlation (with KGWG)
  - Safe Channel study (with KGWG)
- Schumann filter(with LIGO and Virgo) (in October 2016)
- Rough estimation of water GGN (in middle of 2017)

Schedule (Env Monitor)

タスク名	期間	開始日	終了日
Environment	**443日**	**16/07/20 (水)**	**18/03/30 (金)**
Schumann resonance	3日	16/07/20 (水)	16/07/22 (金)
Seismometer	**23日**	**16/08/01 (月)**	**16/08/31 (水)**
[Center] Relocation of the seismometer	23日	16/08/01 (月)	16/08/31 (水)
[Xend] Relocation of the seismometer	23日	16/08/01 (月)	16/08/31 (水)
[Yend] Relocation of the seismometer	23日	16/08/01 (月)	16/08/31 (水)
Thermometer	**88日**	**16/08/01 (月)**	**16/11/30 (水)**
[Center]Thermometer and Hygrometer	23日	16/08/01 (月)	16/08/31 (水)
Pre-Amps for Therm. & Hygro.	22日	16/09/01 (木)	16/09/30 (金)
[Xend] Thermometer & Hygrometer	20日	16/10/03 (月)	16/10/28 (金)
[Yend] Thermometer & Hygrometer	20日	16/10/03 (月)	16/10/28 (金)
DAQ	23日	16/08/01 (月)	16/08/31 (水)
Magnetometer	**110日**	**16/08/01 (月)**	**16/12/30 (金)**
[Mag] Cabling	23日	16/08/01 (月)	16/08/31 (水)
[Mag] Setting up	22日	16/09/01 (木)	16/09/30 (金)
[Mag] Reservation	21日	16/10/03 (月)	16/10/31 (月)
[Mag] Relocation	9日	16/11/01 (火)	16/11/11 (金)

タスク名	期間	開始日	終了日	先
[Mag] Realtime Modeling	22日	16/11/01 (火)	16/11/30 (水)	
[Mag] Add one	22日	16/12/01 (木)	16/12/30 (金)	
Water	**443日**	**16/07/20 (水)**	**18/03/30 (金)**	
Retrieving data at X-arm	3日	16/07/20 (水)	16/07/22 (金)	
interpretation of data during iKAGRA	32日	16/07/19 (火)	16/08/31 (水)	
Modeling water GGN	87日	16/09/01 (木)	16/12/30 (金)	
Software	**444日**	**16/07/19 (火)**	**18/03/30 (金)**	
QuickLook for CRY	45日	16/08/01 (月)	16/09/30 (金)	
Web Based Tools	435日	16/08/01 (月)	18/03/30 (金)	
Updating Daily Summary Page	435日	16/08/01 (月)	18/03/30 (金)	

Schedule for Environmental Monitors



Araya, GIF

Schedule

- Seismometer
  - First: Center at 1st floor, X, Y end at 1st floor (in Sep,2016)
  - After setting up of Digital system on 2nd floor:

    Center at 2nd Floor, X,Y end at 2nd floor
- Thermometer, Hygrometer, Barometer
  - First: Center for one (in Sep, 2016)
  - After setting up of low sampling DAQ
- Magnetometer
  - Cabling in Aug, 2016.
  - Setting up (pre amp,..), and in Sep, 2016
  - Center, after getting 2 more magnetometer, Y,X end

Schedule(Arm Env. Monitor)

As the minimum setup

- Temperature (arm distribution)
- Humidity (arm distribution)
- Air pressure (arm distribution / daily fluctuation)
- Magnetic Field (arm distribution (mainly DC component)

Schedule

- - Nov. 2016
  - Set up at IMS, NINS
  - Test operation at IMS, NINS
- Dec. 2016
  - Test installation at KAGRA
- Jan. – Mar. 2017
  - Adjustment and full installation at KAGRA

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分子科学研究所

END

Channel ↔ Audio Transform