

# KAGRA Detector Characterizationの 開発進捗状況 (IV)

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阪市大)

# Detector Characterization

## Data Analysis

Veto info., target veto , Data quality, calibration accu.

## Detector Characterization

PEM, Aux. channels, Online-monitors, diagnostics

## Instruments

# Detector Characterization

- 望遠鏡が正しく動作しているかどうかを診断
  - 奇妙な発振？ Saturation？ 雑音レベル？
  - カップルしているチャンネルは？ その起源は？
- 環境センサの配置
  - 地震計、磁束計、温度、湿度計、 . . .
- データの状態や質を評価し、サイエンスを最大化させる。
  - 現在の観測データで見える重力波の距離
  - データに含まれている

# 進捗状況：システム、ツール

- **Glitch Monitor**
- **Line Finder**
- **Line Tracking**
- **Line Removal**
- **Rayleigh Monitor**
- **Non-Gaussianity Monitor**
- **RMS Monitor**
- **Noise Floor Monitor**
- **Time-Series Monitor**
- **Spectrum Monitor**
- **Spectrogram Monitor**
- **Sensitivity Monitor**
- **Range Monitor**
  - **Inspiral**
  - **Inspiral-Merger-Ringdown**
  - **Ringdown**
  - **Stochastic**
- **Coherence Finder**
- **Multiple-channel coherence finder (BruCo)**
- **Pearson correlation Finder**
- **NonLinear correlation Finder**
- **Realtime Quick look webpage**
- **Daily summary webpage**
- **GUI Interface**
- **Web-Base Interface**
- **Command-line Interface**
- **Health monitor**
- **File Finder**
- **Globally Correlated magnetic noise**
- **Violin mode**
- **Multi-channel analysis**
- **Newtonian noise**
  - **Effect of water inside the mountain**

# 進捗状況：システム、ツール

相関関係を  
調べる

• **Glitch Monitor**

非定常雑音モニ

• **Line Finder**

ら

• **Line Tracking**

発振などの

• **Line Removal**

ラインモニタ

• **Rayleigh Monitor**

• **Non-Gaussianity Monitor**

ガウス性、定

• **RMS Monitor**

Submitted  
toPRD

常性、非ガウ

• **Noise Floor Monitor**

Yamamoto

ス性

• **Time-Series Monitor**

0+

データの様

• **Spectrum Monitor**

子、スペクト

• **Spectrogram Monitor**

ル

• **Sensitivity Monitor**

• **Range Monitor**

- **Inspiral**

重力波への感

- **Inspiral-Merger-Ringd**

度

- **Ringdown**

- **Stochastic**

• **Coherence Finder**

• **Multiple-channel coherence finder (DRUCC)**

• **Pearson correlation Finder**

• **NonLinear correlation Finder**

Submitted  
toPRD

• **Realtime Quick look webpage**

Yuzuriha  
ra+

• **Daily summary webpage**

• **GUI Interface**

• **Web-Base Interface**

• **Command-line Interface**

インター  
フェース

• **Health monitor**

• **File Finder**

データ保存

• **Globally Correlated magnetic noise**

チェック

• **Violin mode**

• **Multi-channel analysis**

• **Newtonian noise**

- **Effect of water inside the mountain**

# aLIGOで有効なものを吸収

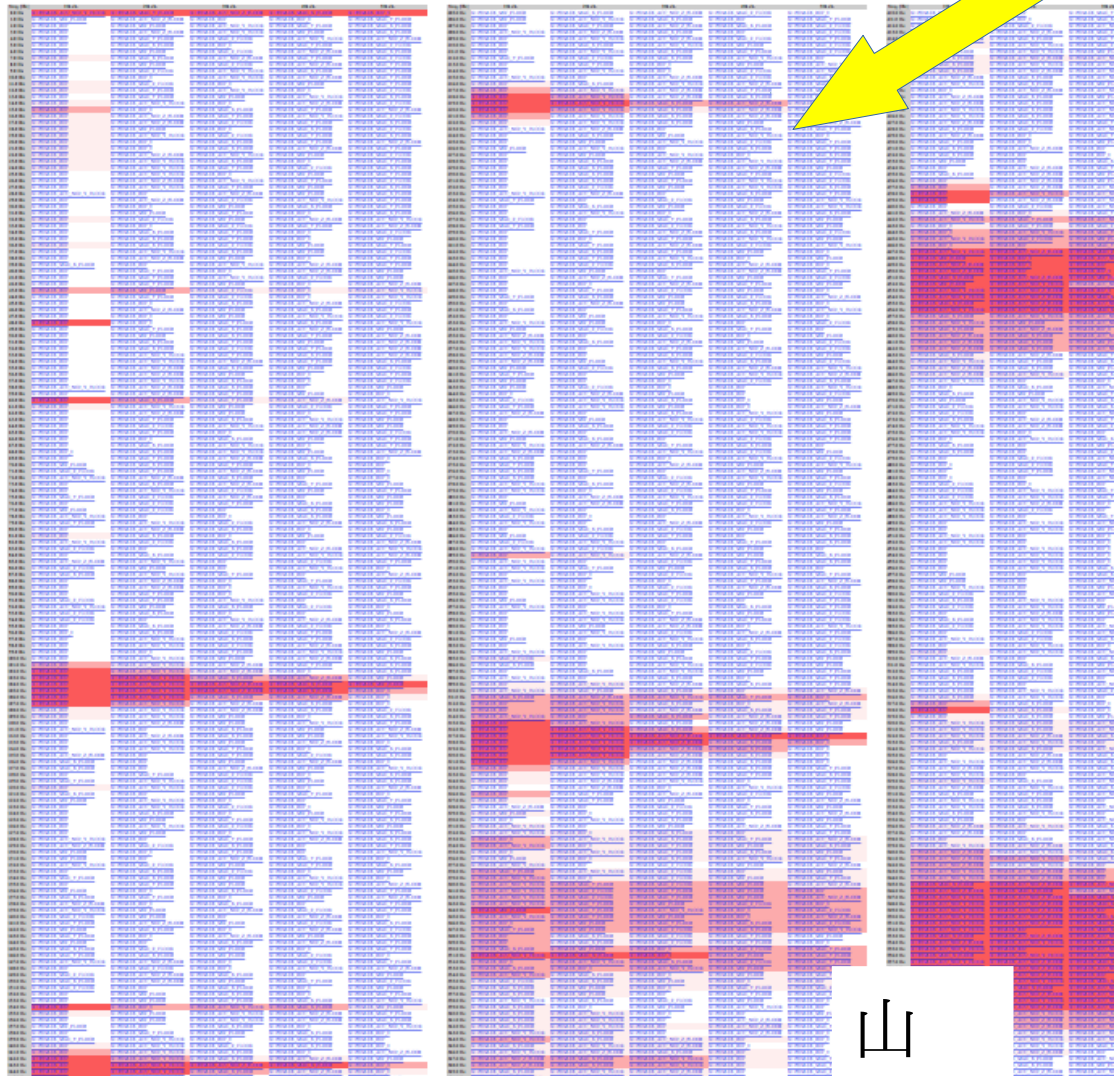
## HasKAL

GPS Time: 1120543424 (2015-07-10 06:03:27 UTC)

Channel: K1:PEM-EX\_ACC\_NO2\_X\_FLOOR

0.0Hz~

205.0Hz~



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

### Realtme Quick look webpage

- Daily summary webpage
- GUI Interface
- Web-Base Interface
- Command-line Interface
  
- Health monitor
- Globally Correlated magnetic noise
- Violin mode
- Multi-channel analysis
- Newtonian noise
  - Effect of water inside the mountain

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# Preparation of monitoring system

[General](#)   [VIS](#)   [IOO](#)   [Bruc](#)   [Web Tools](#)

Daily Summary Page

### Calendar

**Feb. 2016**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1 2 3 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

**Jan. 2016**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1 2 3  
 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 31

**Dec. 2015**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1 2 3 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 31

**Nov. 2015**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1  
 2 3 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

**Oct. 2015**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1 2 3 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 31

**Sep. 2015**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1 2 3 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

**Aug. 2015**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1 2  
 3 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  
 31

**Jul. 2015**  
 Mon. Tue. Wed. Thu. Fri. Sat. Sun.  
 1 2 3 4 5

**K1:PSL-PMC\_TRANS\_DC\_OUT\_DQ**

<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:TimeSeries</b> 	<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:Spectrum</b> 	<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:Spectrogram</b> 
<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:RMSMon</b> 	<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:SensMon</b> 	<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:LTF</b> 
<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:RMon</b> 	<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:SRMon</b> 	<b>K1:PSL-PMC_TRANS_DC_OUT_DQ:LTA</b> 

**K1:PSL-PMC\_MIXER\_OUT\_DQ**

<b>K1:PSL-PMC_MIXER_OUT_DQ:TimeSeries</b> 	<b>K1:PSL-PMC_MIXER_OUT_DQ:Spectrum</b> 	<b>K1:PSL-PMC_MIXER_OUT_DQ:Spectrogram</b> 
<b>K1:PSL-PMC_MIXER_OUT_DQ:RMSMon</b> 	<b>K1:PSL-PMC_MIXER_OUT_DQ:SensMon</b> 	<b>K1:PSL-PMC_MIXER_OUT_DQ:LTF</b> 

# Web-Based Tools

[Single Channel Analysis](#)
[Coherence Analysis](#)
[Correlation Map](#)
[Bruco](#)
[Detection Range](#)
[Daily Summary page](#)

Date:

GPS Time: 1134572417  
 Local Time:  
 2015 Dec 20  
 00:00 JST

Channel List:

[make channel list](#)  
[select channel list \(Default\)](#)

Channel 1:

- K1:PSL-FSS\_FAST\_MON\_OUT\_DQ
- K1:PSL-FSS\_MIXER\_OUT\_DQ
- K1:PSL-FSS\_PC\_MON\_OUT\_DQ
- K1:PSL-FSS\_REFL\_DC\_OUT\_DQ
- K1:PSL-FSS\_SLOW\_MON\_OUT\_DQ

Parameters:

For General  
 Duration:  sec. (default is 32s)  
 Freq. band:  Hz ~  Hz  
 (default is from 0Hz to Nyquist freq.)

Monitors:

Pearson Correlation  MIC

plot view

## HasKAL

GPS Time: 1134572417 (2015-12-19 15:00:00 UTC)

duration: 32s Freq. band: 0 - fNyquist Hz

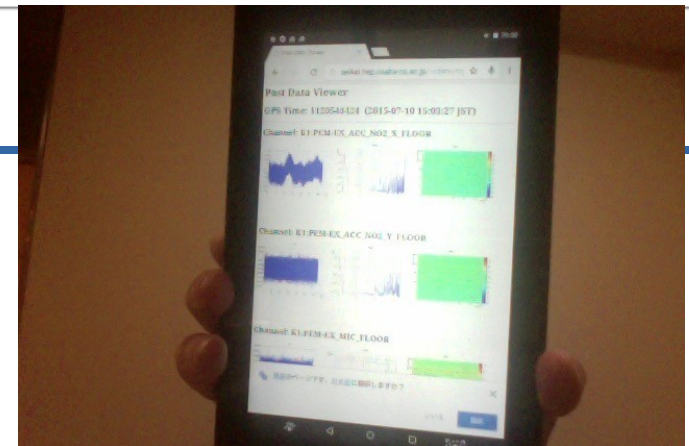
	K1:PSL-FSS_FAST_MON_OUT_DQ	K1:PSL-FSS_MIXER_OUT_DQ	K1:PSL-FSS_PC_MON_OUT_DQ	K1:PSL-FSS_REFL_DC_OUT_DQ	K1:PSL-FSS_SLOW_MON_OUT_DQ
K1:PSL-FSS_FAST_MON_OUT_DQ	1.00000	0.01447	0.02042	NaN	0.01939
K1:PSL-FSS_MIXER_OUT_DQ	0.01447	1.00000	0.01804	NaN	0.01404
K1:PSL-FSS_PC_MON_OUT_DQ	0.02042	0.01804	1.00000	NaN	0.02279
K1:PSL-FSS_REFL_DC_OUT_DQ	NaN	NaN	NaN	1.00000	NaN
K1:PSL-FSS_SLOW_MON_OUT_DQ	0.01939	0.01404	0.02279	NaN	1.00000

Get URL

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Real time quick look page is [here](#)

Powered by [HasKAL](#)



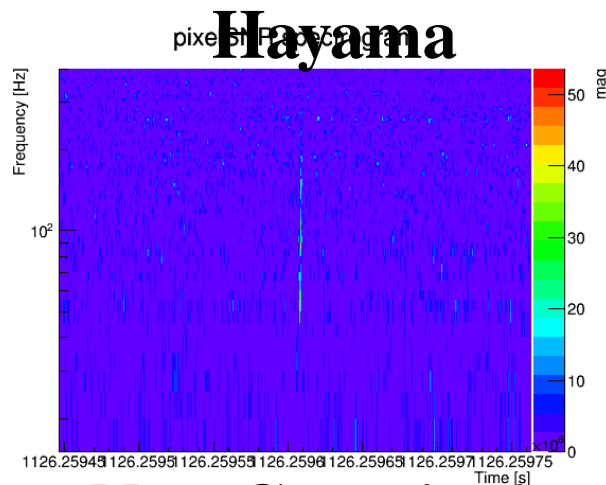


# Example : GW150914

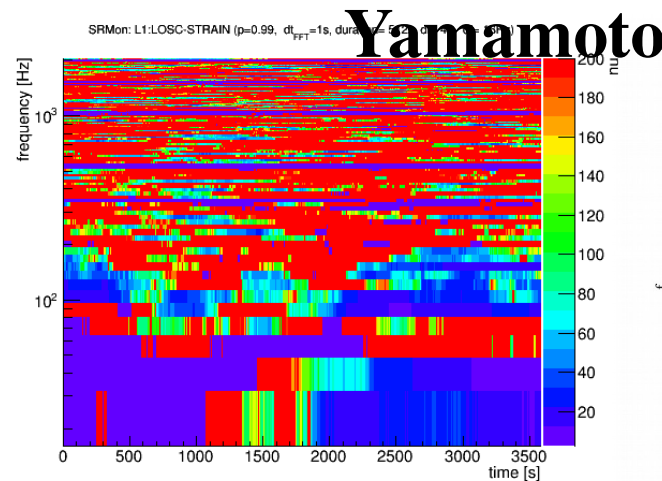
## Data Characterization around GW150914

- Seen the signal clearly
- Amp. of Power line(60Hz) fluctuated  $\sim \pm 5E-21$
- Amp. of 500Hz line decreasing
- $> 100\text{Hz}$ , Gaussianity pretty good
- $< 100\text{Hz}$ , non-Gaussian
- 516Gz line: strange behavior.

### Glitch pipeline

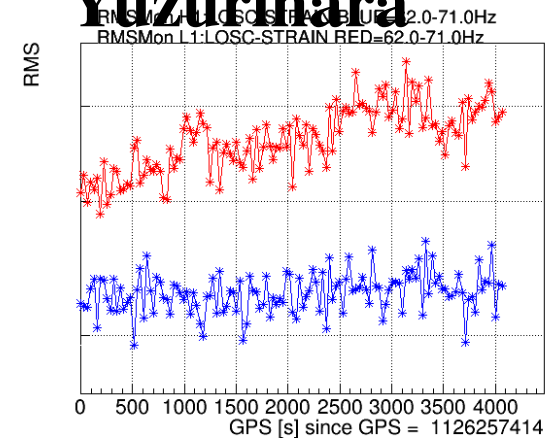


### Non-Gaussianity

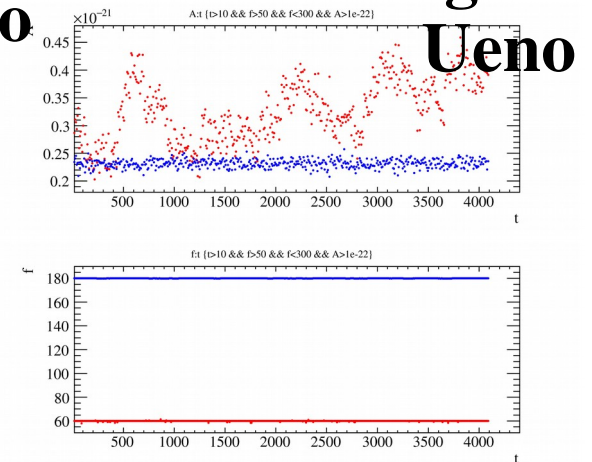


### BLRMS (60~70Hz)

#### Yuzurihara



### Line Tracking





## Next

### KAGRA試験観測前半

- 干渉計信号のDetcharシステムによるモニタ
- システムティックなデータ評価基準の定義

### KAGRA試験観測後半

- 環境雑音の測定
- KAGRA観測に向けてのフィードバック

# Option

# KAGRA発の評価法を開発

- **Glitch Monitor**

- **Line Finder**

- **Line Tracking**

- **Line Removal**

- **Rayleigh Monitor**

- **Non-Gaussianity Monitor**

- **RMS Monitor**

- **Noise Floor Monitor**

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- **Spectrum Monitor**

- **Spectrogram Monitor**

- **Sensitivity Monitor**

- **Range Monitor**

- **Inspiral**

- **Inspiral-Merger-Ringdown**

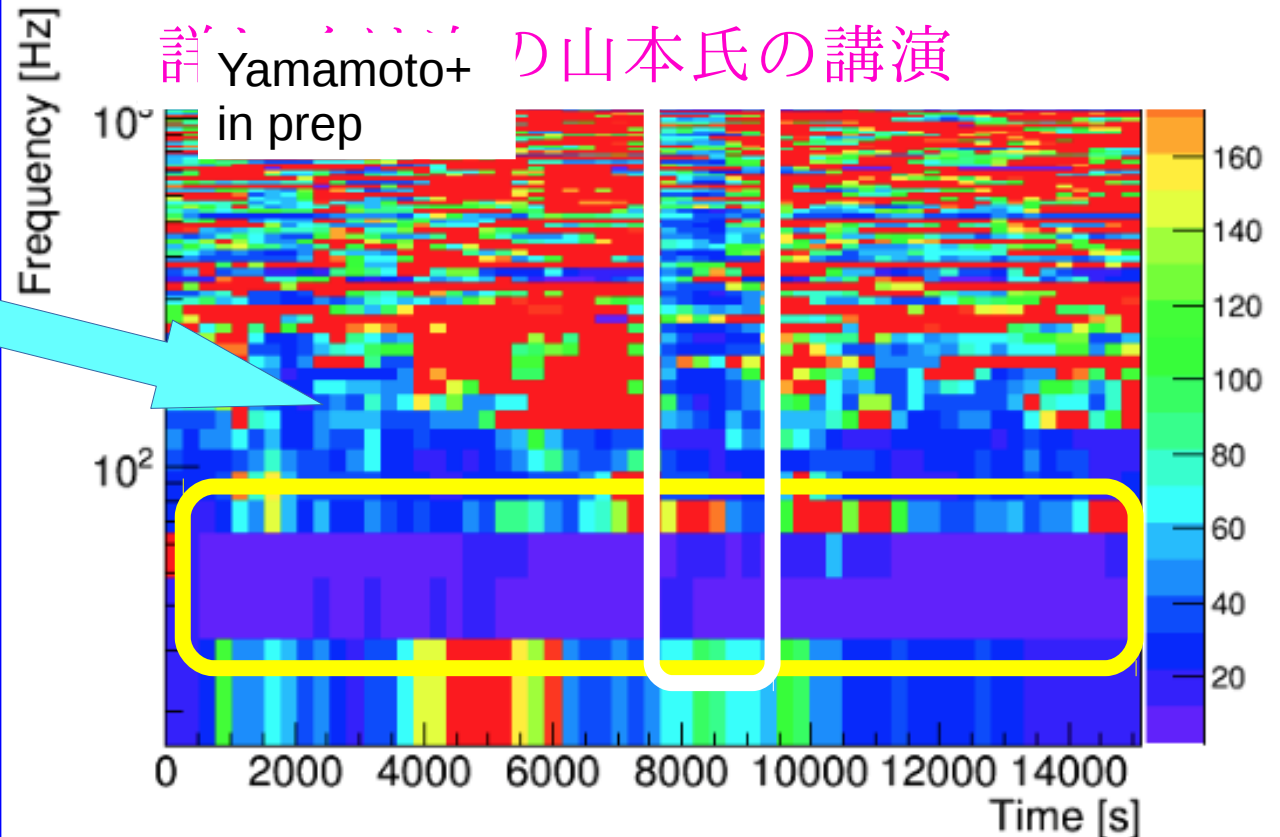
- **Ringdown**

- **Stochastic**

定常非ガウス性、数100秒スケースの非ガウス性、それらの周波数依存性を発見し、詳細を調べる

詳細はYamamoto+山本氏の講演

in prep



This research has made use of data, software and/or web tools obtained from the LIGO Open Science Center (<https://losc.ligo.org>), a service of LIGO Laboratory and the LIGO Scientific Collaboration. LIGO is funded by the



# KAGRA発の線形でない相関を発見する手法の開発

- Glitch Monitor

- Line Finder
- Line Tracking
- Line Removal

- Rayleigh Monitor
- Non-Gaussianity Monitor

## 手法の開発

- Coherence Finder

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

- Real-time Quick look webpage

- Daily summary webpage

- GUI Interface
- Web-Base Interface
- Command-line Interface

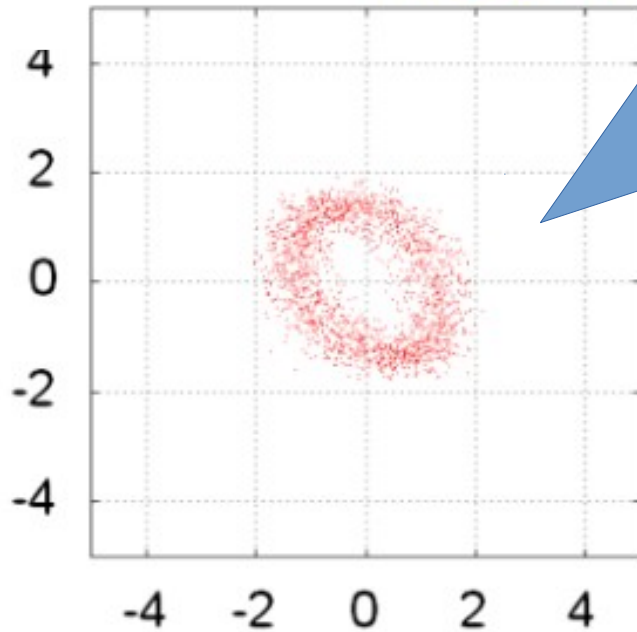
- Health monitor
- Globally Correlated magnetic noise
- Violin mode
- Multi-channel analysis
- Newtonian noise

- Effect of water inside the mountain

Yuzurihara+  
in prep

重力波チャンネル

相関がある時刻



譲原

加速度計チャンネル

- Stochastic

enoshima authored 18 hours ago latest commit df515b023e

HasKAL

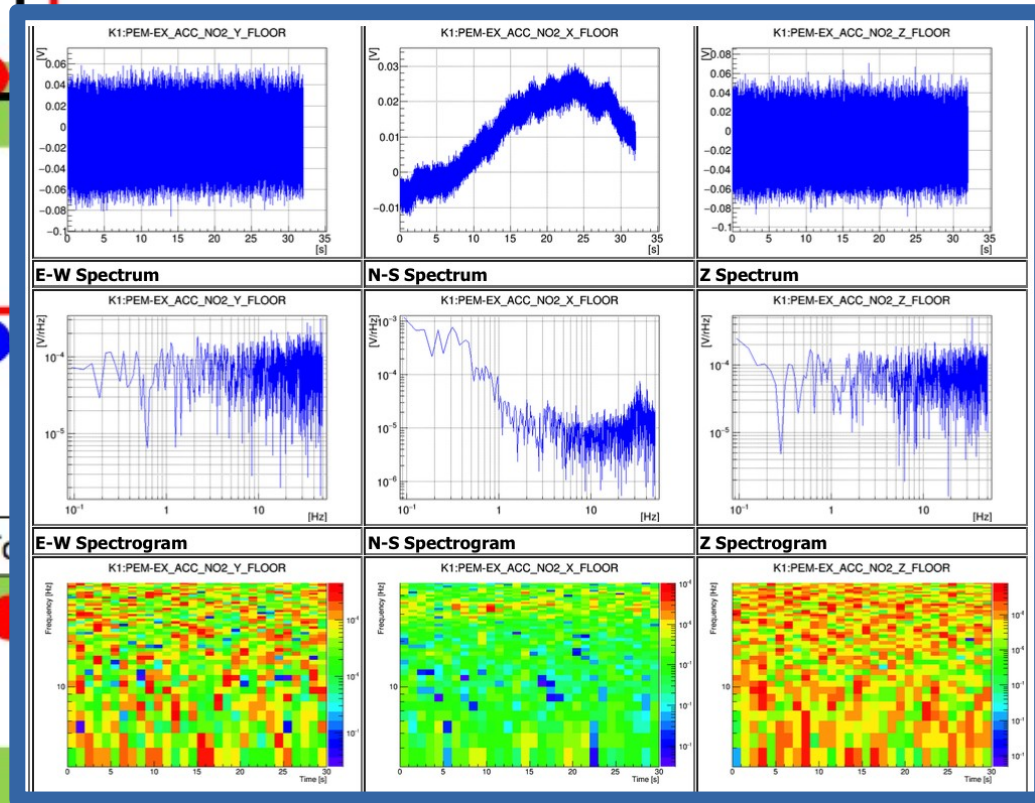
..		
Constant	remove haddock header	2 months ago
DataBaseUtils	added function	2 months ago
DetectorUtils	small change	22 days ago
ExternalUtils	bug fixed in DKGLUtils.c	10 days ago
FrameUtils	remove haddock header	2 months ago
GUI_Utils	modified GUI for StochMon update	11 days ago
LineUtils/LineRemoval	modify a sample kagali code	26 days ago
MathUtils/LinearAlgebra	changed directory structure	3 days ago
Misc	remove haddock header	2 months ago
MonitorUtils	RMSMon : modify daily RMSMon and measure running time	9 days ago
PlotUtils	added new function for spectrogram plot	19 hours ago
SearchUtils	added SearchUtils	a year ago
SignalProcessingUtils	added function	18 hours ago
SimulationUtils	remove unnecessary comment	2 months ago
SpectrumUtils	remove function runmed and unnecessary comment	2 months ago
StatisticsUtils	change module name	a year ago
TimeUtils	added function for converting time	a month ago
WaveUtils	add dropWaveData, takeWaveData	a year ago
WebUtils	minor update	10 days ago
Constant.hs	remove haddock header	2 months ago
DataBaseUtils.hs	added DataBaseUtils related	3 months ago
DetectorUtils.hs	added module of modules	a year ago
TimeUtils.hs	added module-setting module	a year ago
WaveUtils.hs	added a module-setting file	a year ago
WebUtils.hs	added blank	2 months ago

<https://github.com/gw-analysis/detector-characterization>

# 環境モニタ

## X-Endで環境モニタ

2nd floor

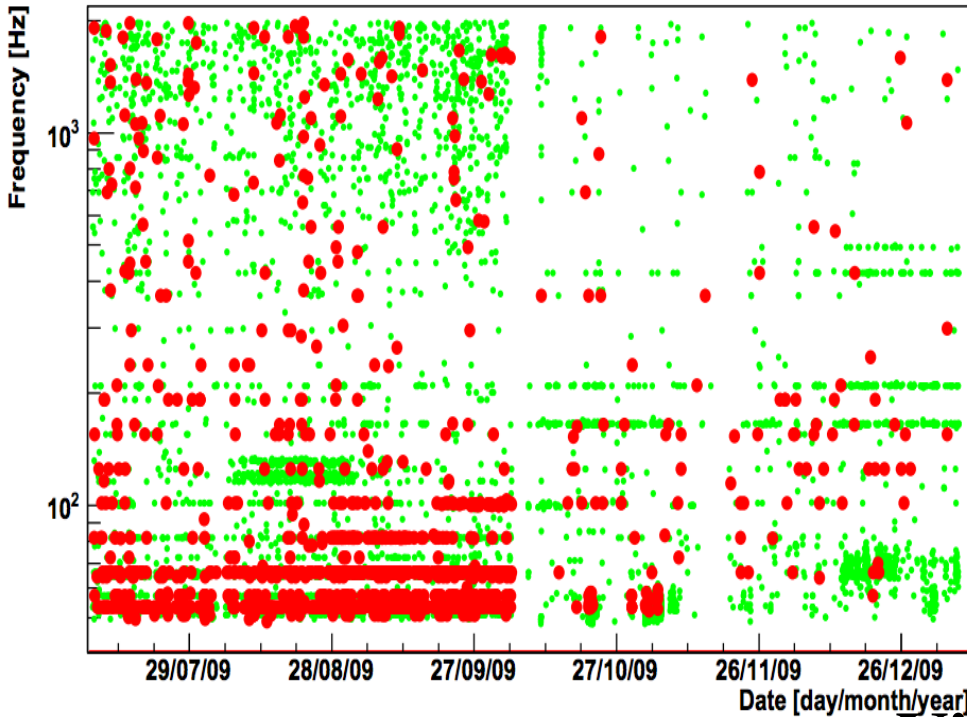


d floor

500m



# 重力波望遠鏡の観測データ（例）



	Line categories	Number of identified lines
Intrinsic lines	Violin modes	127
	Mechanical resonances	26
	Calibration and control	32
Noise lines	Power line and harmonics	40
	Vibration	24
	Magnetic	-
	Digital	73
	Sidebands	640

Virgo

Virgo

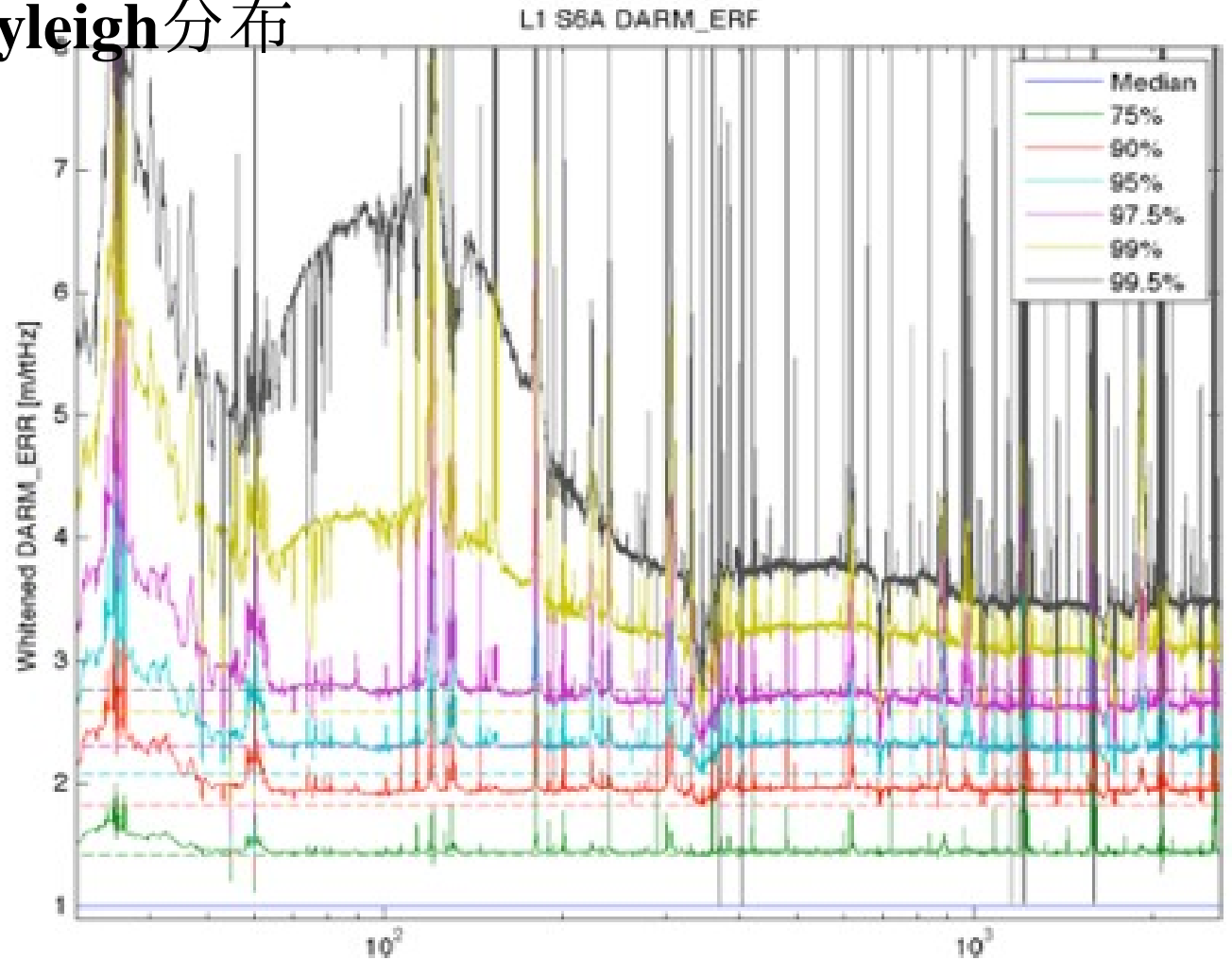
SNR>5のイベント  
が毎秒1.8個

1390のラインのうち、  
起源が特定できたのは**960**個

重力波発見を宣言には、こういった起源不明の雑音を特定、除去していかなければならない。

# データの（定常、非定常）非ガウス性

## Rayleigh分布



LSC



