

Status of KAGRA Detector Characterization

**Kazuhiro Hayama (Osaka City Univ.)
on behalf of the detector characterization group**

Interface of the detector characterization

Data Analysis

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

Detector Characterization

PEM, Aux. channels, Online-monitors, diagnostics

Instruments

Two Direction : To provide system, tools for

- **Detector diagnostics, speed-up commissioning**
- **Monitor data quality, Veto analysis**

Subsystem detector characterization

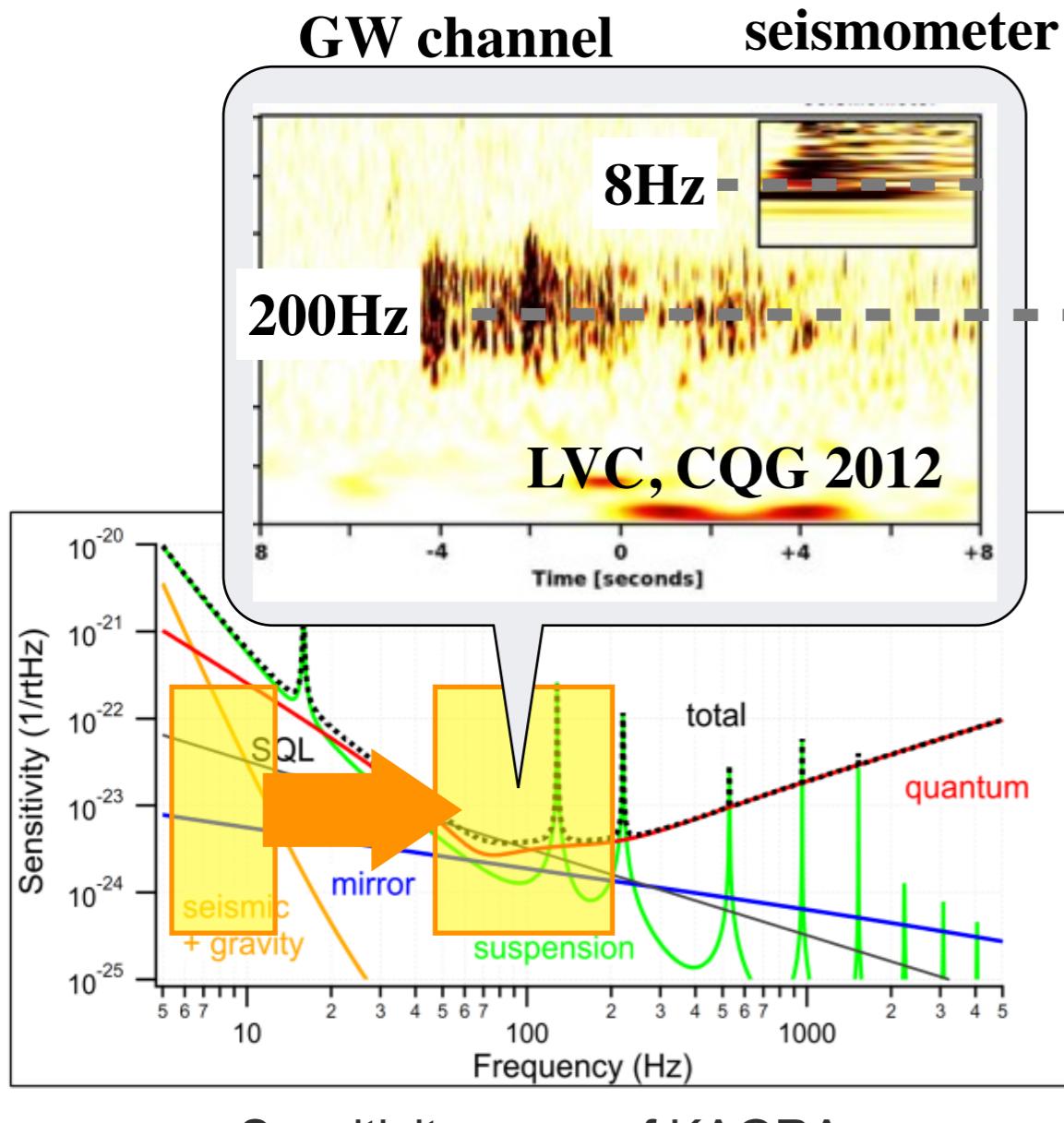
Speed-up commissioning

- Single Subsystem Diagnostics
 - ADC noise is within range?
 - Whitening requirement?
 - Channel correlated noise?
 - Find good frequency region for calibration
 - Components consisting the subsystem is working correctly?
 - Noise budget
 - Kill source of glitches, lines
- Will provide tools to do these effectively.
- Important to cooperate with subsystems at early phase of the development. (First, with VIS people)

Multiple-subsystem characterization

Speed-up commissioning

Example of correlated noise between subsystems



- Need to watch channels over subsystems
- **Up-conversion noise:** seismic glitches will excite optical bench motion which cause scattered light noise.
-> AOS-VIS channels
- **Non-linear correlation analysis** between multiple subsystems,
Multi variate analysis using lots of channels will be important to find/understand/kill such noise source.

Data quality monitor, Veto Analysis

Data quality Evaluation

Category	Definition	Prescription for analyses
CAT1	Flags obvious and severe malfunctions of the detector.	Science data are re-defined when removing CAT1 segments.
CAT2	Flags noisy periods where the coupling between the noise source and the DF is well-established.	Triggers can be automatically removed if flagged by a CAT2 veto. Good performance.
CAT3	Flags noisy periods where the coupling between the noise source and the DF is not well-established.	CAT3 flags should not be applied automatically. Triggers flagged by a CAT3 veto should be followed up carefully.

LVC

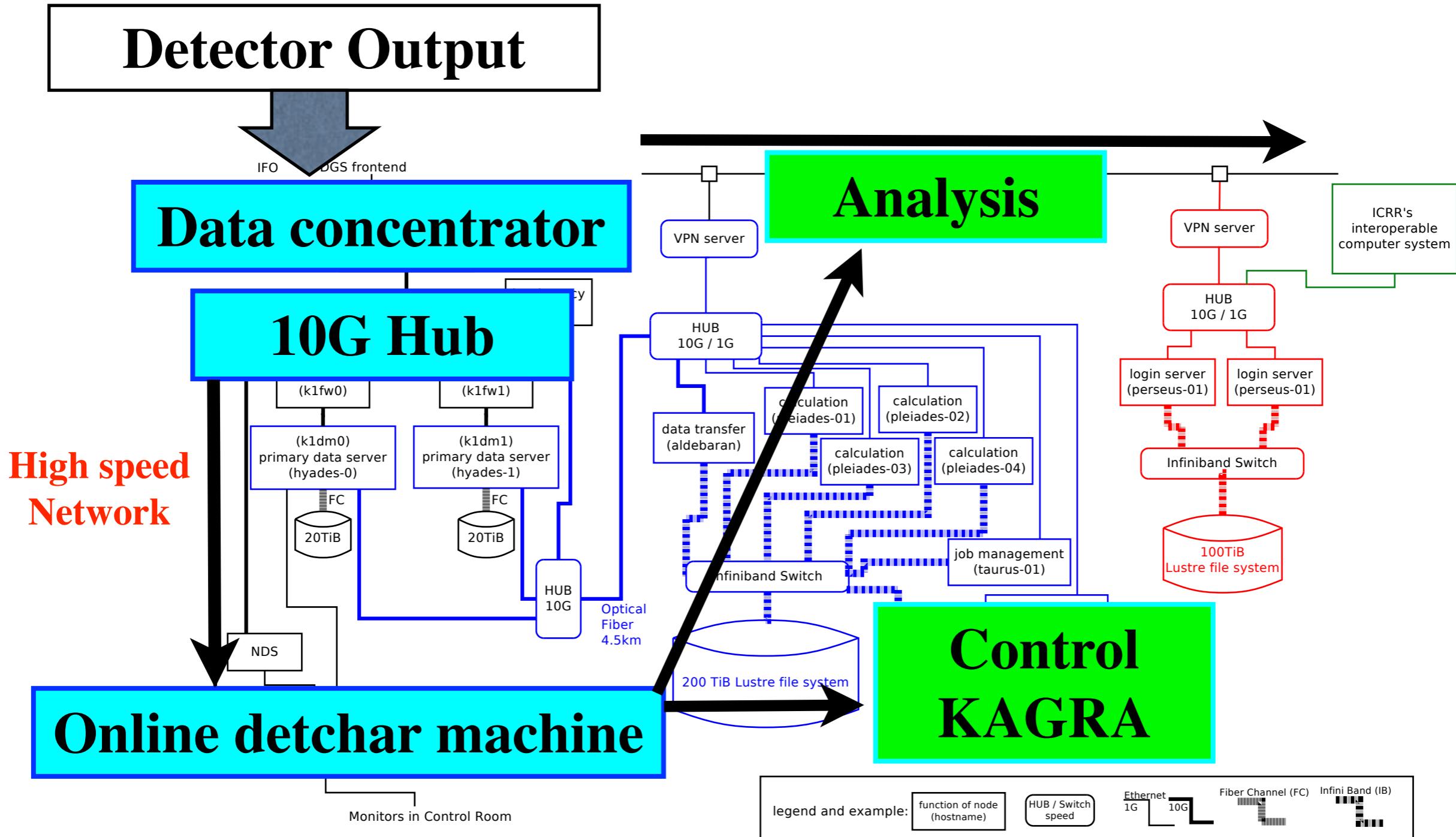
Fast channels



Post processing : Veto Analysis for doing Science

Veto list generation		
Transient GW (CBC, Burst)	Continuous GW (pulsar, LMXB, ...)	Stochastic GW (Early Univ, ...)
<ul style="list-style-type: none">• Real-time glitch detection• Glitch classification• Coincidence analysis between the GW channel and auxiliary sensor channels.• ...	<ul style="list-style-type: none">• Line tracking• Line detection• Removal of high frequency spikes• ...	<ul style="list-style-type: none">• Noise floor monitor• Non-stationary• ...

Detector Characterization Cluster



Realtime Channel Monitor

Kanda

DetChar projects

Primary Projects

- To maintain Diagnostics Test Tool
- Detchar GUI
- Glitch Monitor
- Line Monitor
- Noise Modeling
- Rayleigh Monitor
- Noise Floor Monitoring
- Range Monitor
(Inspiral,
Ringdown,
Insp-Merger-Ringdown)
- Noise Budget
- Health Monitor
- Data base
- Quality flag
- Detchar summary page

Special Projects

- Globally correlated mag noise
- Violin mode
- Multi-Channel Analysis
(with Korea detchar, Mano)
- Detchar shift plan
- Newtonian Noise
 - in progress
 - in slowly progress

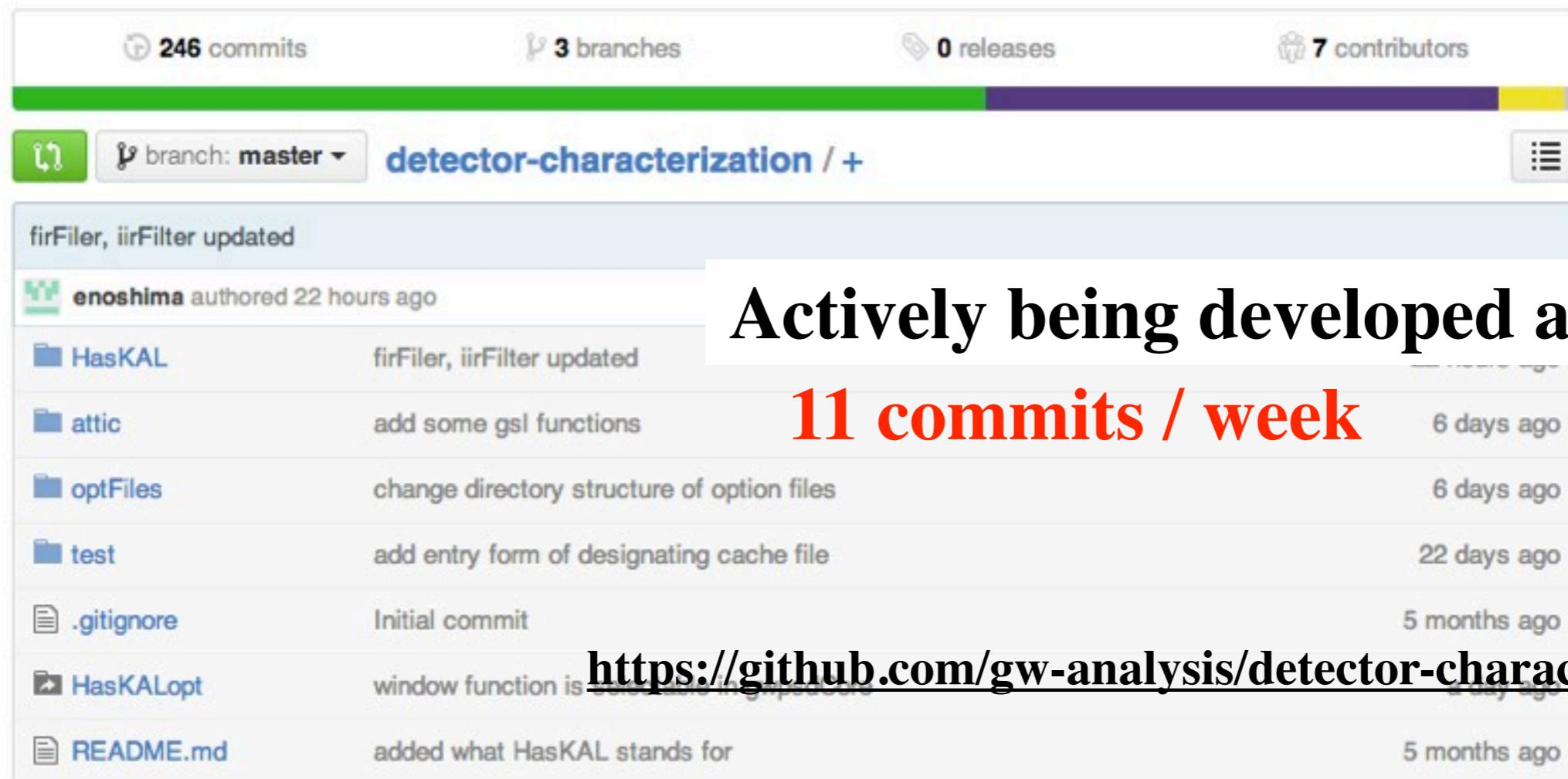
Noise Characterization at the KAGRA site



HasKAL : DetChar tools/system

- Haskell-based analysis software package
 - Runtime Error FREE by strong type checking system
 - Easily integrate KAGALI, LAL, FrameLib,..
 - Short debugging time by short lines

Tools for gravitational wave detector characterization — Edit



Structure of HasKAL

branch: master ▾

[detector-characterization](#) / HasKAL / src / HasKAL / +

firFiler, iirFilter updated

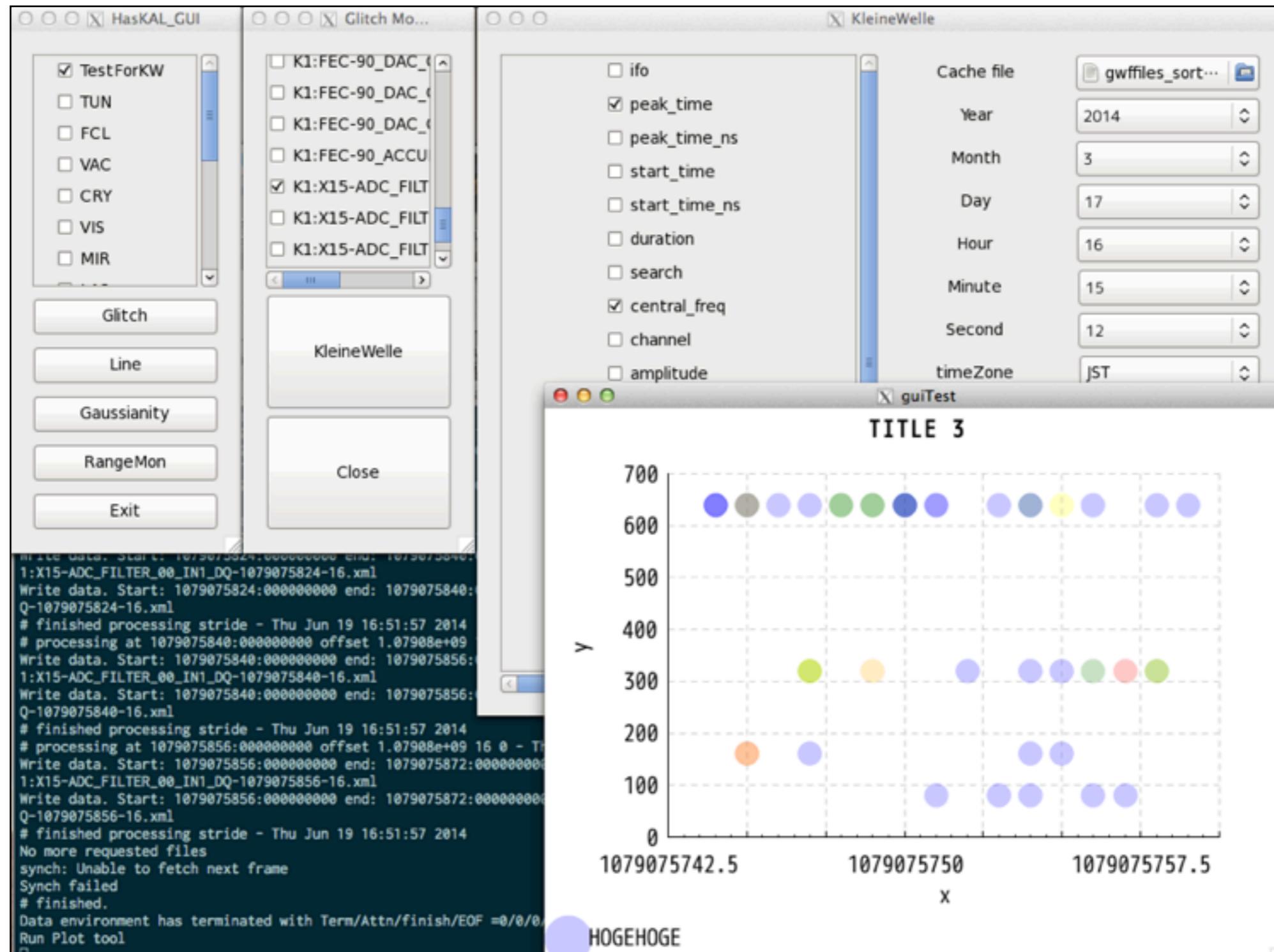
 enoshima authored 22 hours ago

..

 DetectorUtils	Detector.hsfixed
 ExternalUtils	change time-variable from String to Tuple
 FrameUtils	modified PickUpFileName.hs
 GUI_Utils	change time-variable from String to Tuple
 MonitorUtils	change time-variable from String to Tuple
 PlotUtils	remove argument of tapplication from module
 SignalProcessingUtils	firFiler, iirFilter updated
 SpectrumUtils	window function is selectable in gwpsdCore
 TimeUtils	generate timetuple2gps by Yokozawa

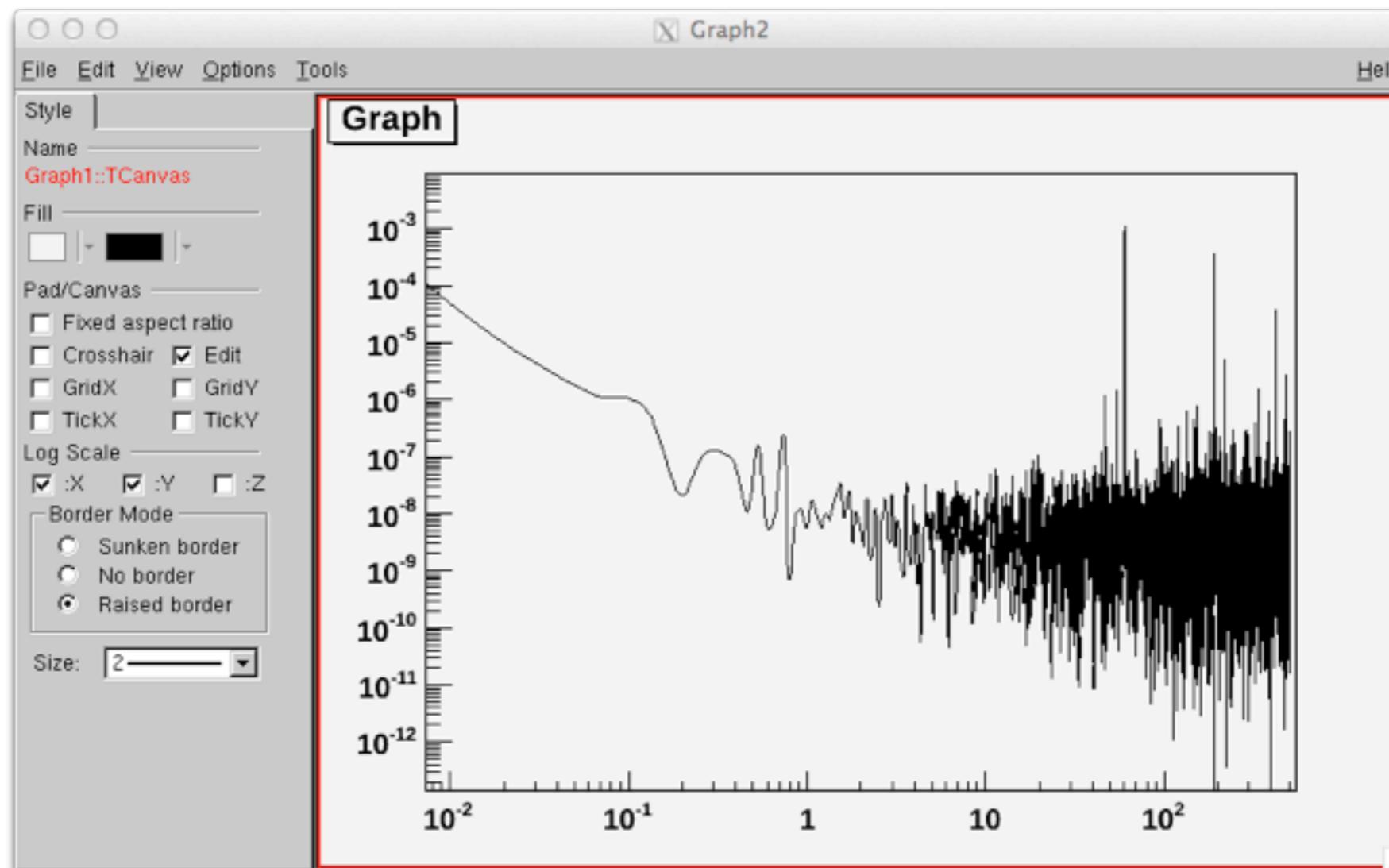
DetChar GUI

Running Glitch Monitor (kleineWelle)



Yamamoto+

ROOT based plotting

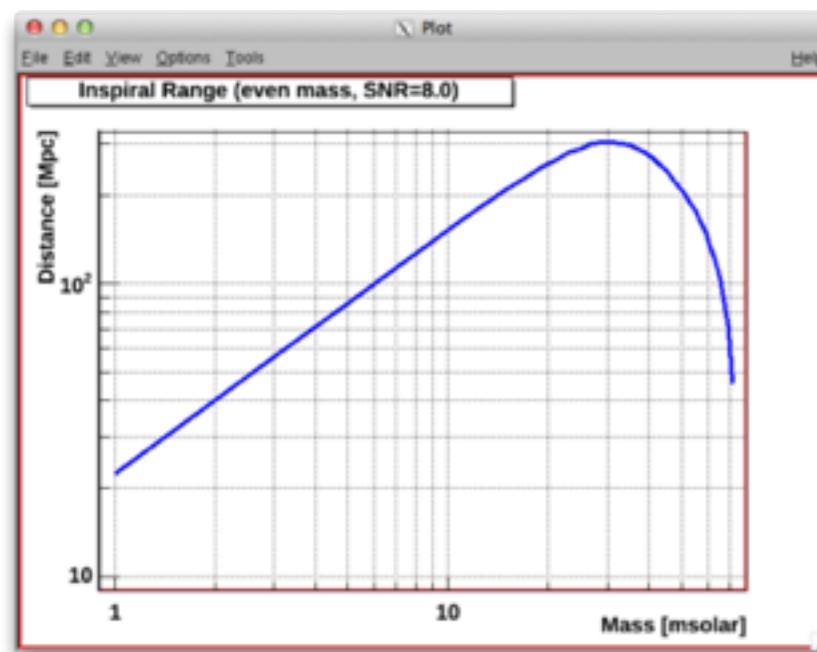


Yuzurihara

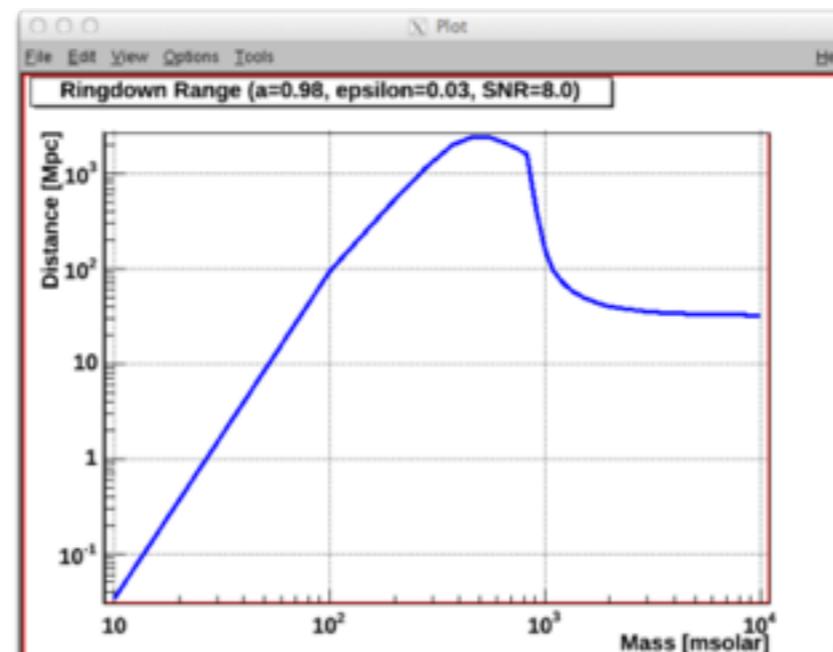
Range Monitor

Characterizing telescope sensitivities

Inspiral



Ringdown



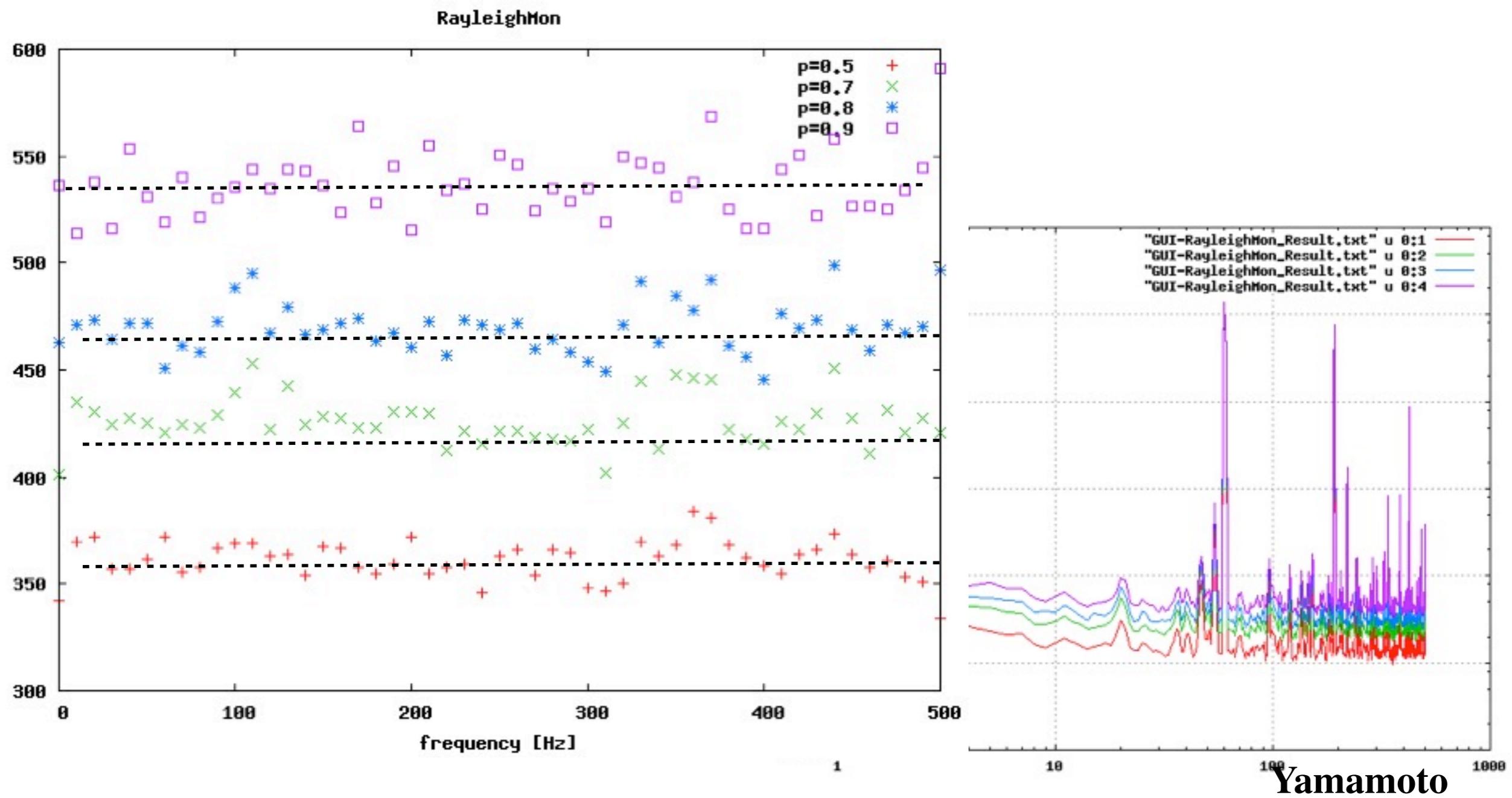
IMBH
(Inspiral+Merger+Ringdown)



Ono, Hayama

Rayleigh Monitor

Investigating noise behavior at various frequency regions

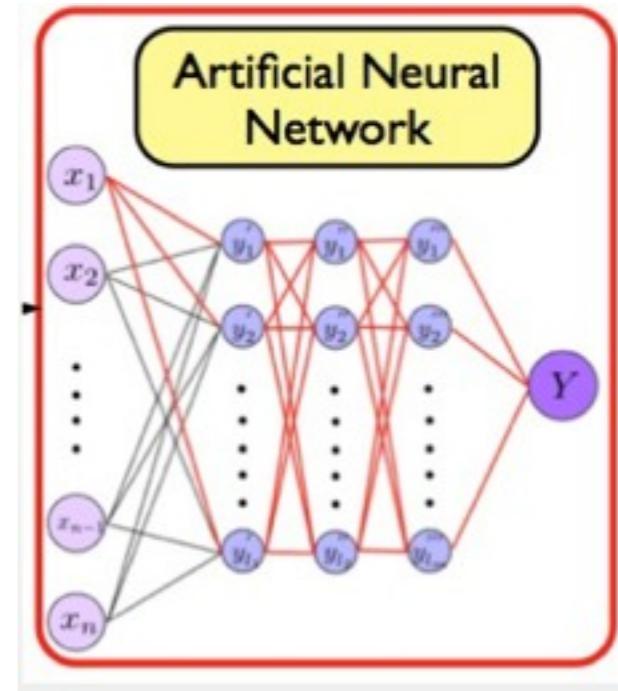


Development of New Noise Characterization Tools

- **Realtime non-Gaussian noise modeling**
 - In reality, even stationary noise is different from Gaussian noise.
- **Non-linear correlation analysis between Aux channels**
- **Globally detector network monitor**

Multi-Channel Analysis

- Lead by Korean GW group
- Initial Goal:
 - Development of a method **for localize noise sources using auxiliary channels and PEMs to support find/ kill noise sources.**
 - **KGWG has been developing ANN based one for post-processing analysis in LVC.**
 - **We focuses on a tool useful for commissioning.**
- **Account to access KISTI cluster**

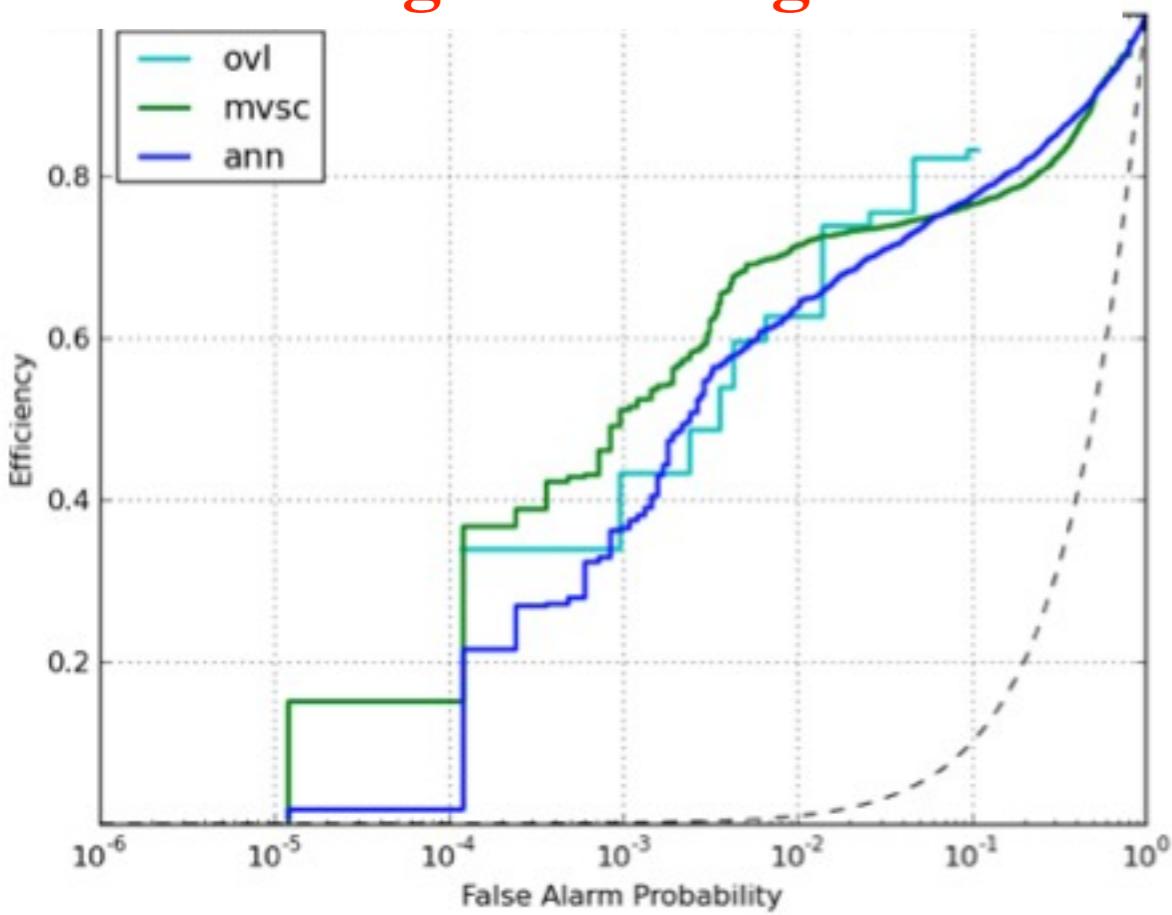


Integrating iDQ into HasKAL

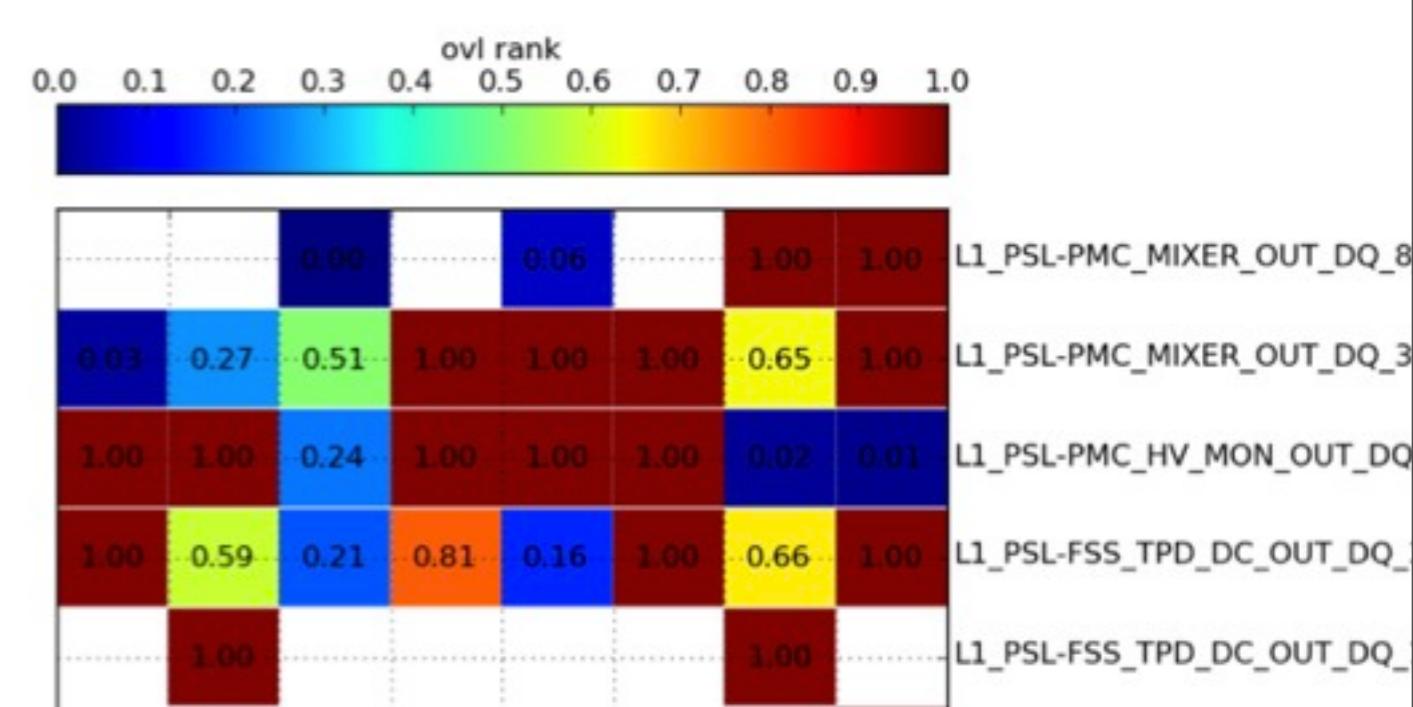
- a low-latency pipeline which makes event-by-event predictions about the glitchiness of GW data based on auxiliary channel informations and provides data quality information.
- Finding responsible channels of glitches

Will Integrate iDQ in HasKAL.

Recie
Improvement of efficiency by removing artificial glitches



Finding glitch-introduced channels



Young-Min Kim (Pusan Nat'l Univ.)
Japan-Korea KAGRA DetChar Call @ April 22, 2014

Data quality study (cryogenic glitches)



Daisuke Tatsumi (NAOJ)

Reduction of **cryogenic induced glitches**

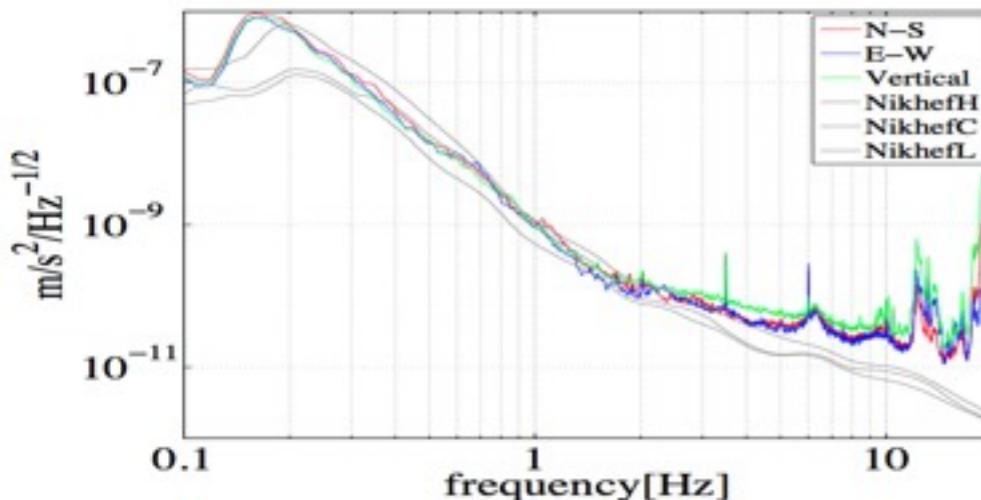
KAGRA is a unique cryogenic detector in the world.
We have to a method to quality the data condition.

- A noise monitoring system for the cryogenic system is developed at TAMA 300.
- Our goal is to develop a system to reduce the false alarm rate to 1/month.

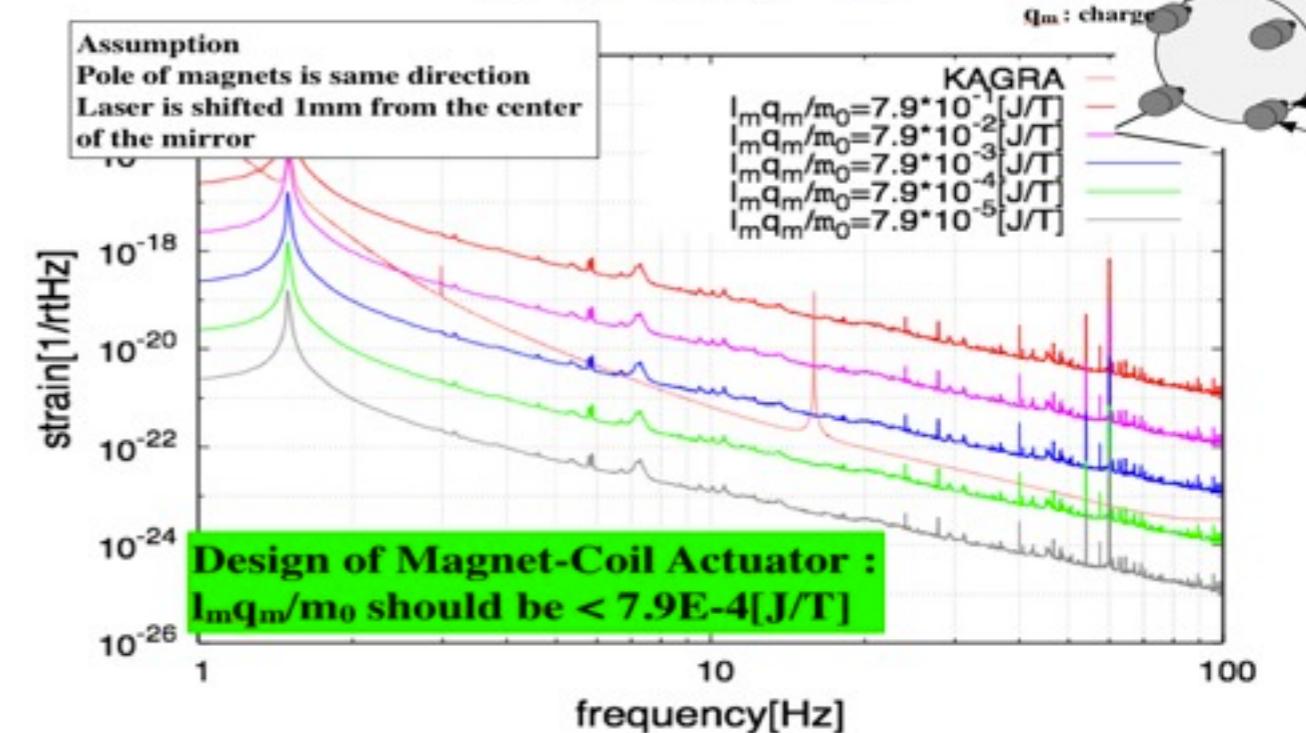


Noise Characterization at the KAGRA site

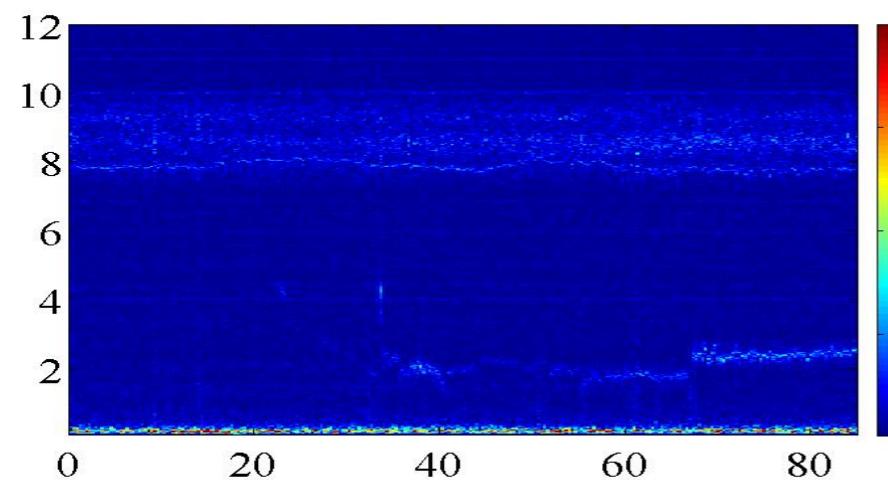
Seismic noise : < 2Hz
consistent with CLIO
high frequency under investigation



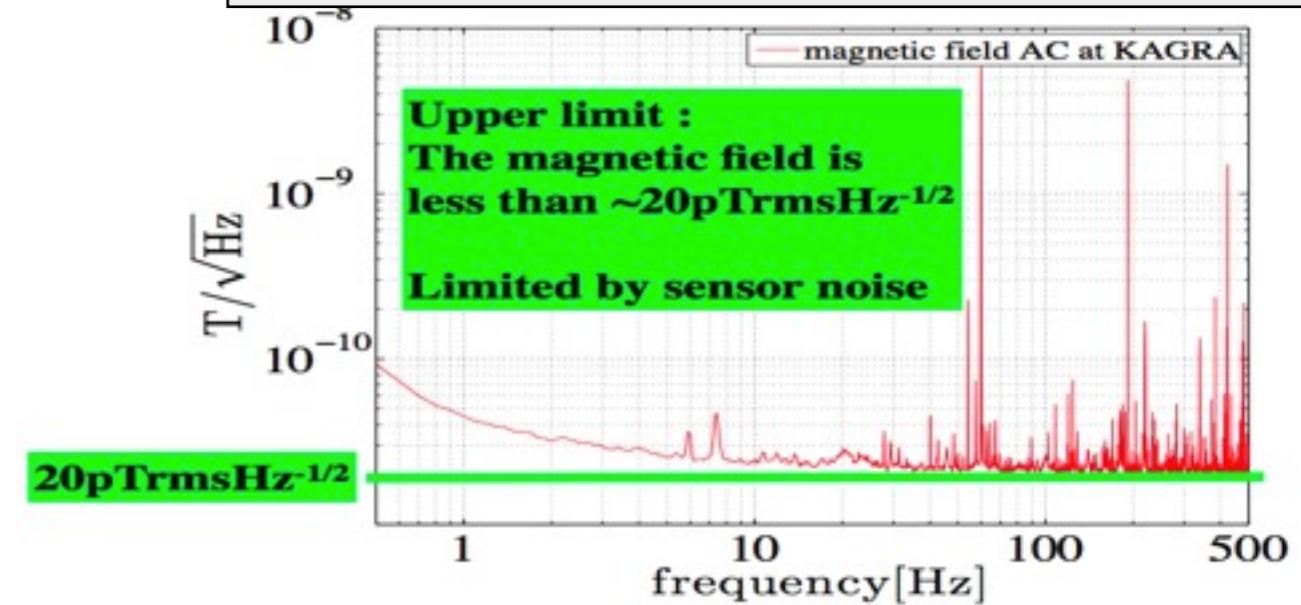
magnetic field : Requirement of
Coil-magnet actuator



Stationarity: not bad, but
longer data needed



No strange magnetic sources

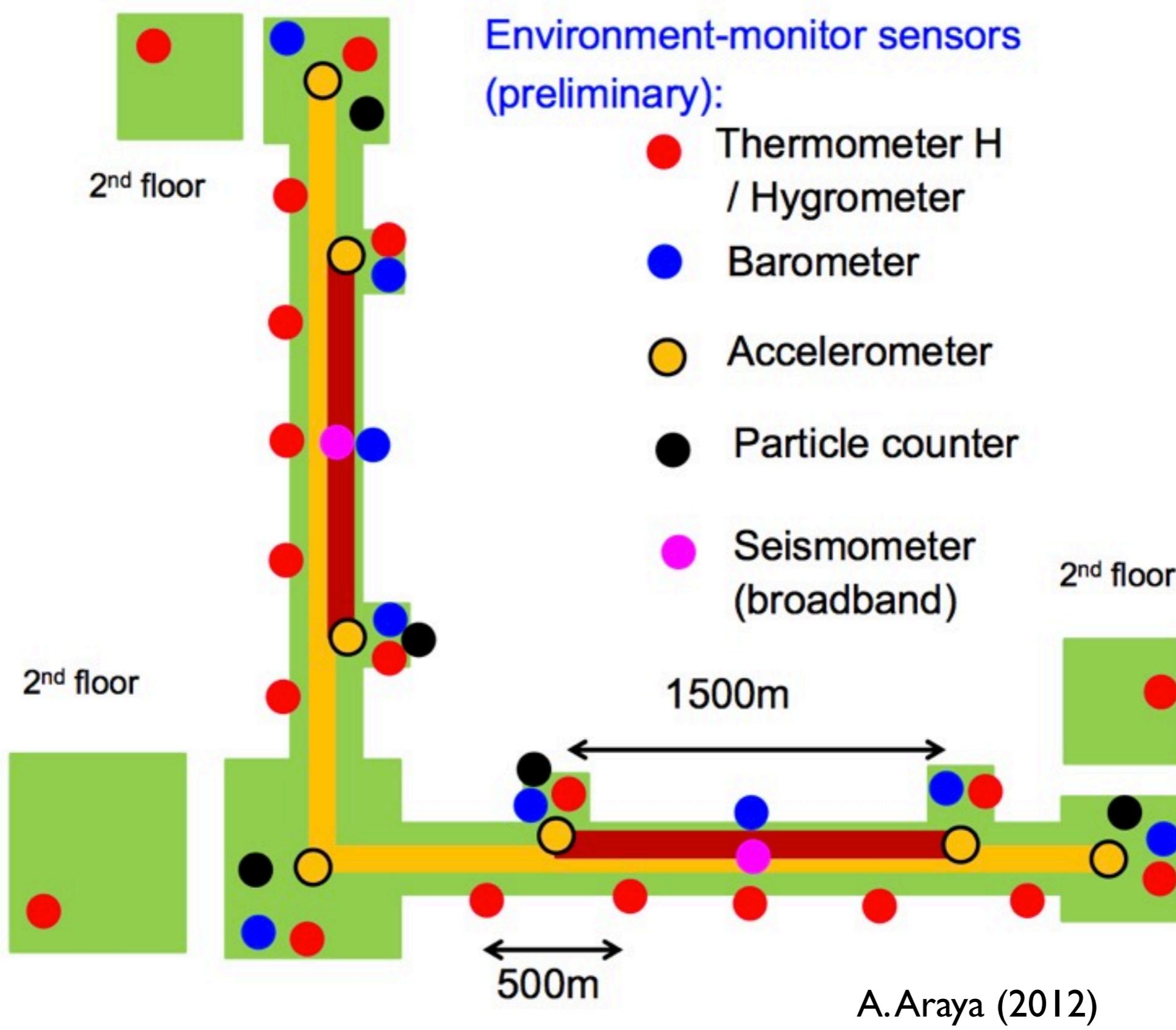


Schedule

- 2014 June : Installation of detchar GUI on VIS digital system at NAOJ so that we get advice, feedback from VIS people**
- 2014 Oct ~ : GIF will start operate some of environmental monitors. These monitor data will be retrieve by same digital system as KAGRA. We will do test-operation of the detchar system/tools using the monitor data.**
- 2014Oct-2015Dec Updating system and tools.**



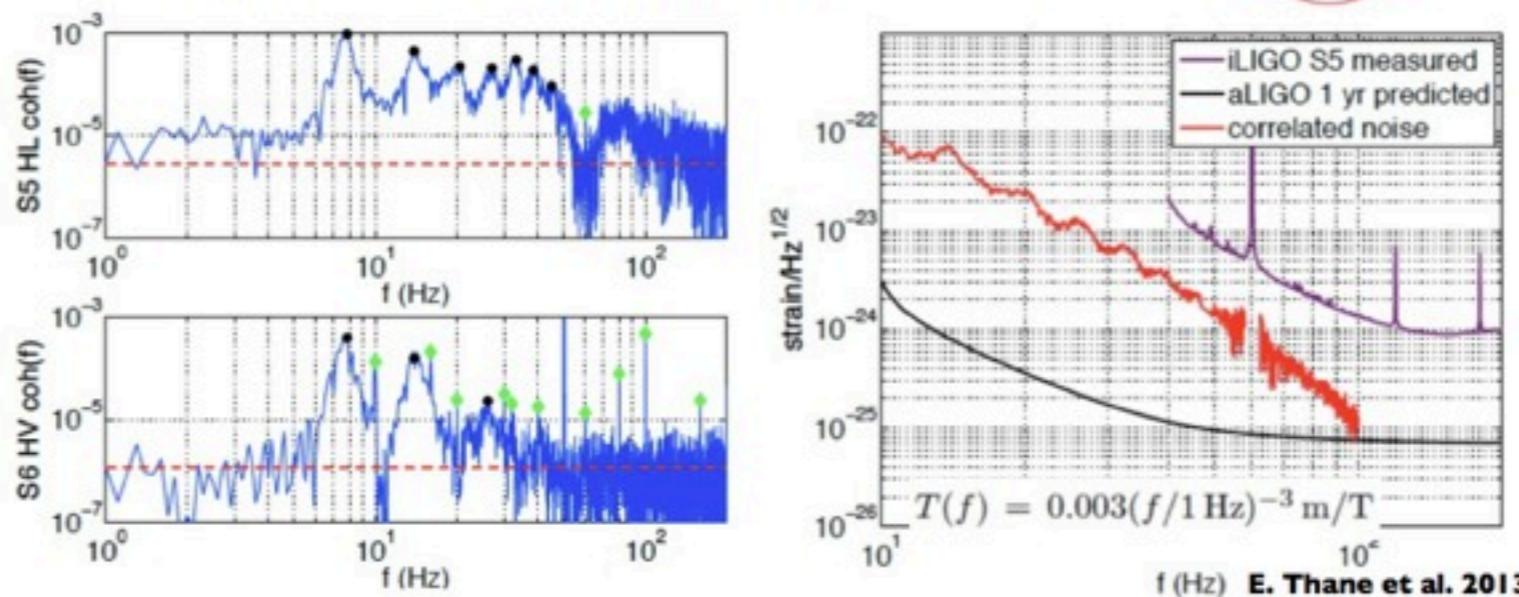
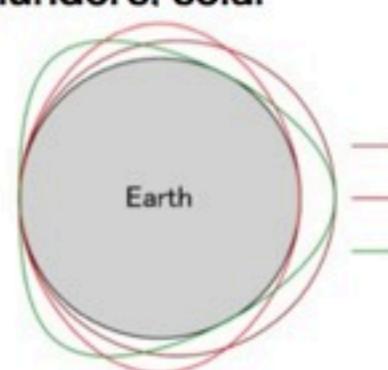
Environmental Monitors



S : Globally Correlated Magnetic Noise

Global correlated magnetic noise

- Schumann resonance
Resonance of the ionosphere due to discharge of thunders, solar wind,...
- very weak ($0.5\text{-}1\text{E-}12\text{T/rHz}$) (Earth's: $1\text{E-}5\text{T}$)
- Long coherent length ~1000km
- Correlation shows up by 1year integration



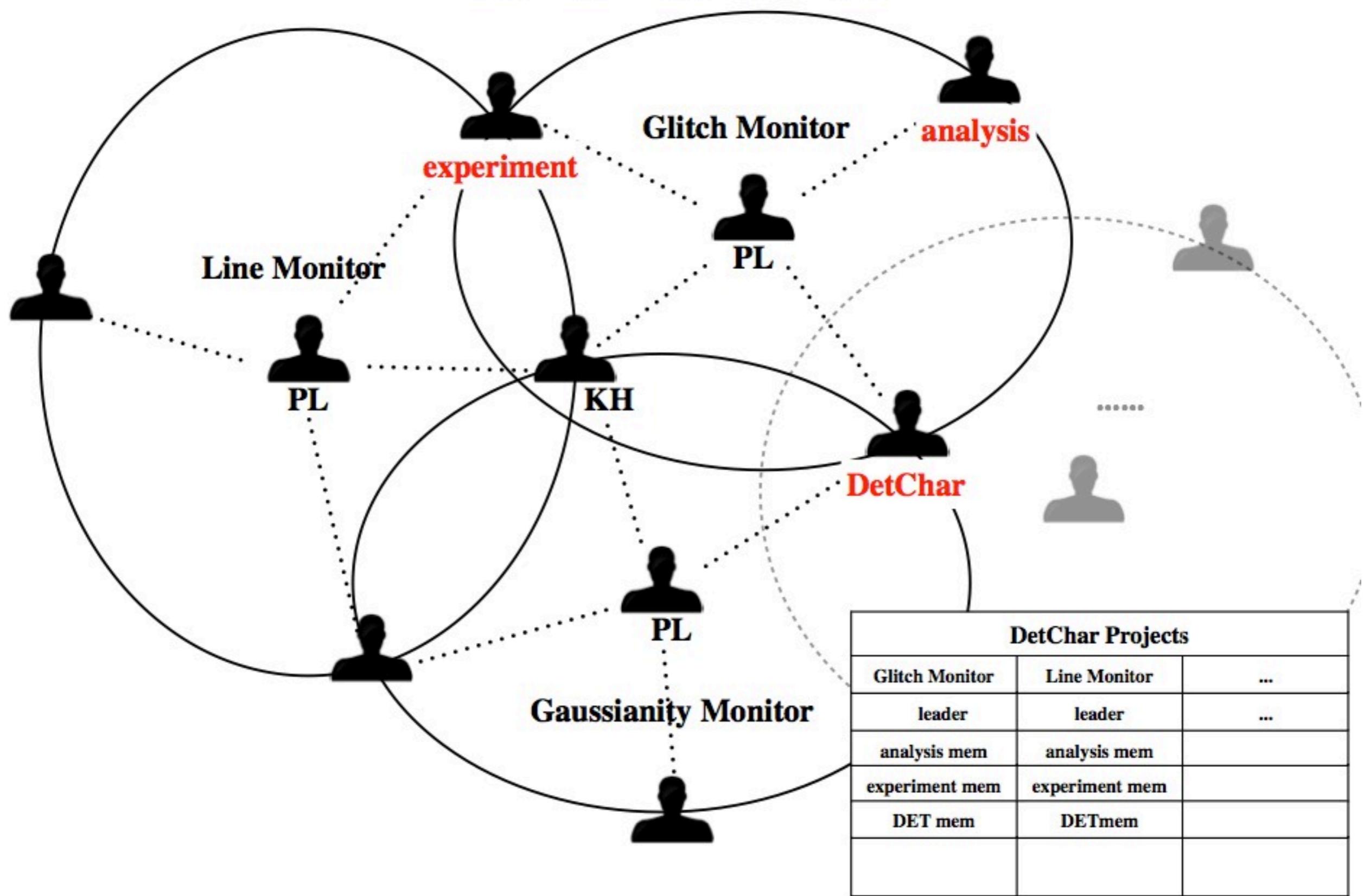
Influence on SGWB search

detector pair	$h_0^2 \Omega_{\text{gw}}$ w/o magnetic noise	$h_0^2 \Omega_{\text{gw}}$ w/ magnetic noise	degradation factor
HL	5.5×10^{-9}	2.5×10^{-8}	4.55
HV	2.4×10^{-8}	4.1×10^{-8}	1.71
LV	2.0×10^{-8}	3.5×10^{-8}	1.75
KH	3.8×10^{-8}	5.0×10^{-8}	1.31
KL	6.4×10^{-8}	7.7×10^{-8}	1.20
KV	2.2×10^{-8}	3.4×10^{-8}	1.54

表 1: Detectable $h_0^2 \Omega_{\text{gw}}$ with SNR = 5 for 1 yr observation time. Note that when correlation noise limits the sensitivity to Ω_{gw} , longer observation time does not help improve the sensitivity.

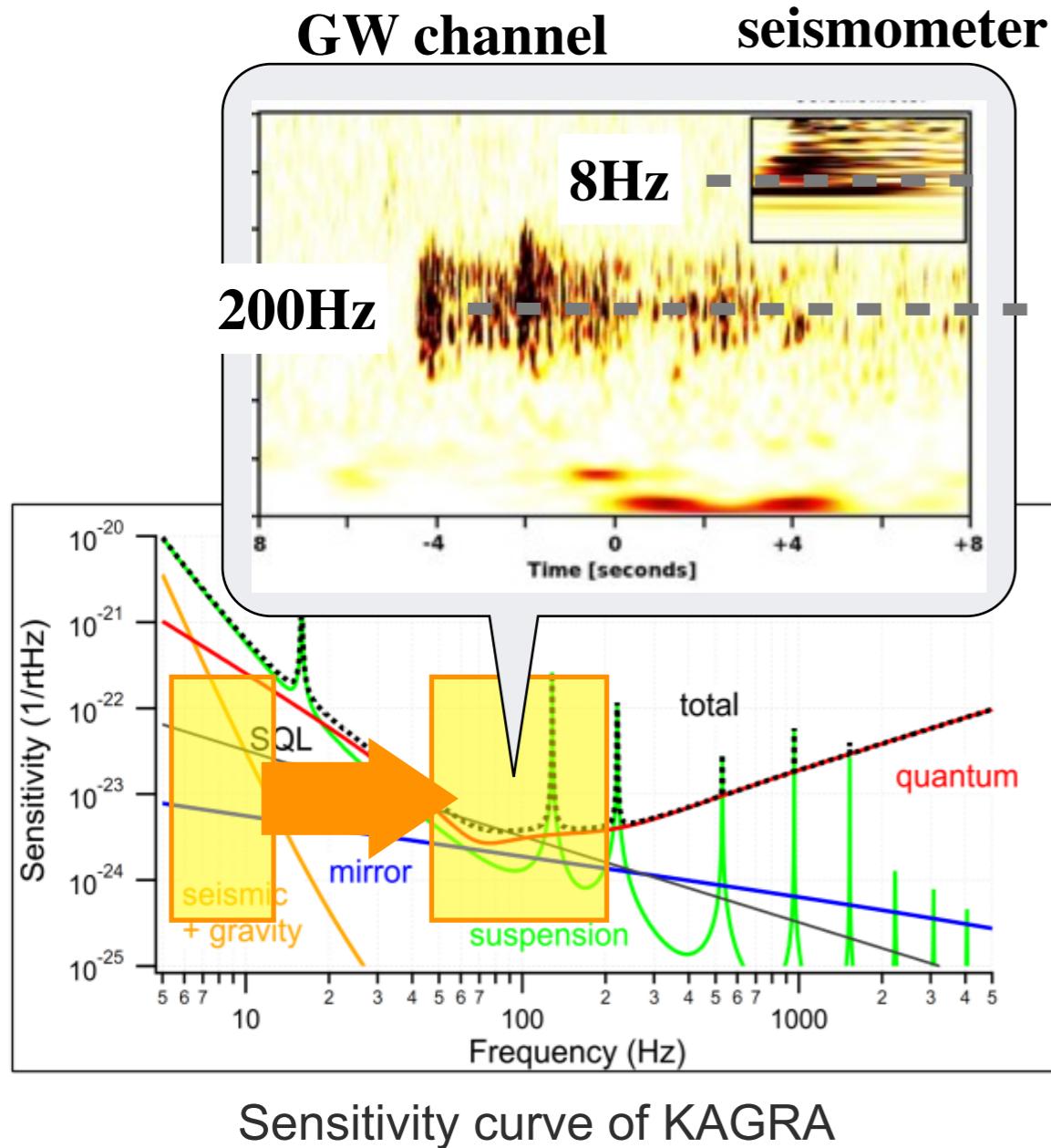
Atsushi Nishizawa
Kyoto Univ.

Structure of the projects

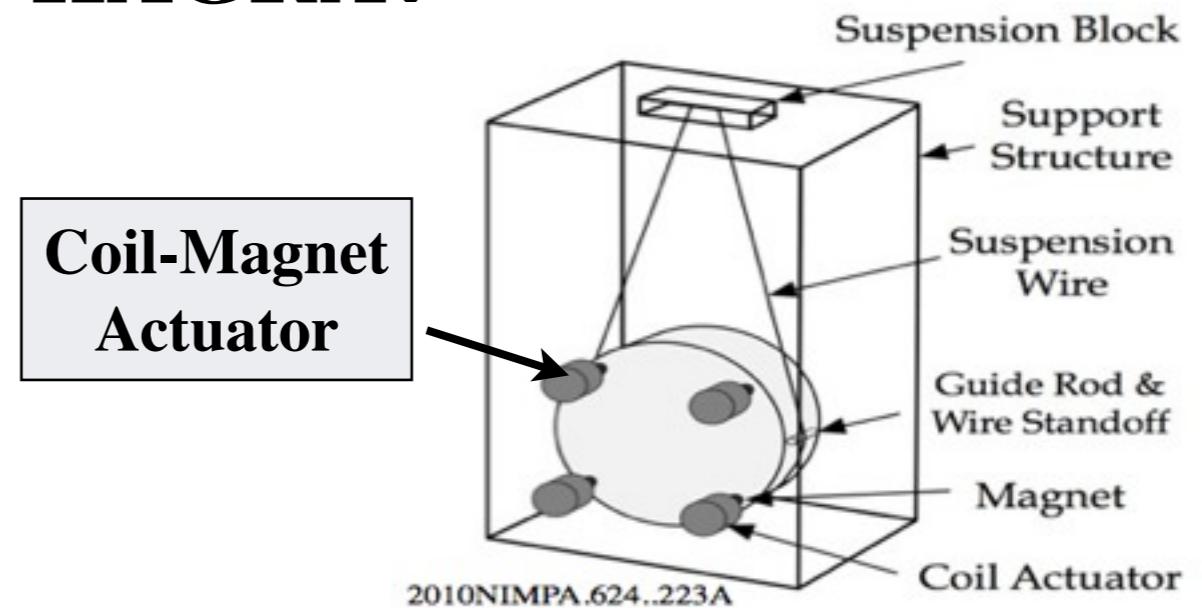


Noise Characterization

What about Seismic Up-Conversion Noise ?

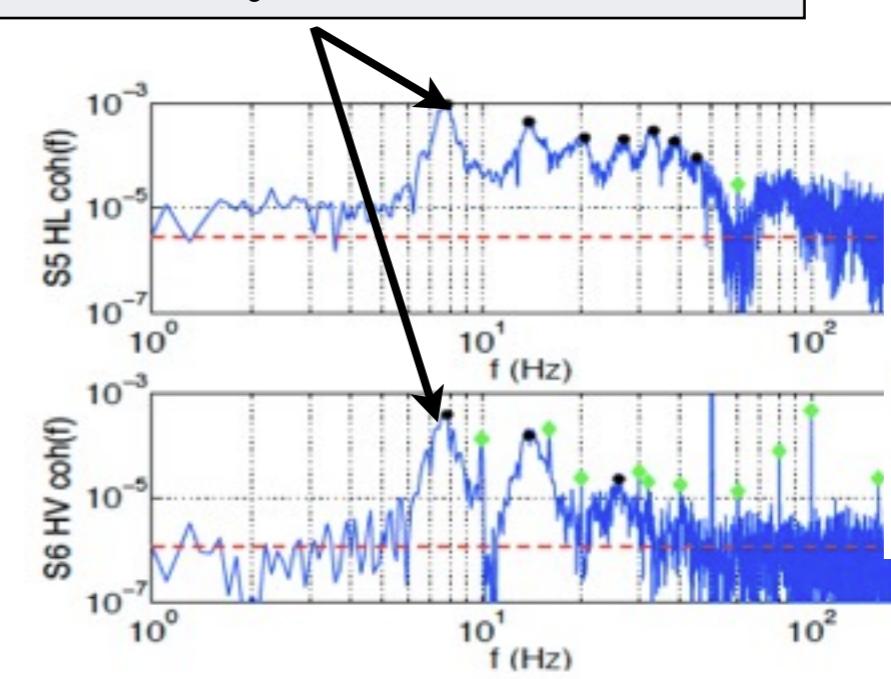


How magnetic field affects KAGRA?

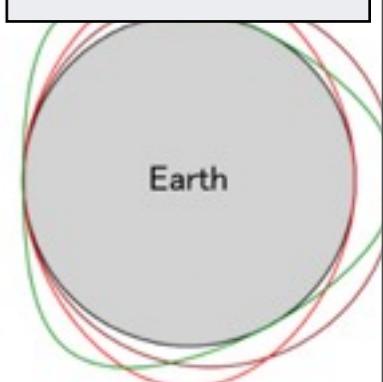


Coil-Magnet
Actuator

Globally correlated noise



Schumann
resonance



Location of the measurement



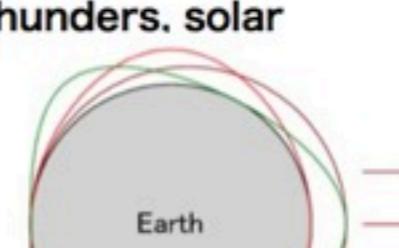
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Atsushi Nishizawa
Kyoto Univ.

Discussing possibility of Direct measurement of Schumann resonance at the KAGRA site collaboration with geophysicists at OCU.

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Rana's Comment at External Review

DetChar:

1) A way to maximize the utility of DetChar in speeding the commissioning progress in the early days is for the commissioning team to construct well-defined start-up projects for the DetChar team. An example of one created for LIGO is here:

https://nodus.ligo.caltech.edu:30889/wiki/doku.php?id=detector_commissioning_characterization_projects

2) It would be helpful to have remote interferometer experts able to do remote monitoring and data analysis during the commissioning phase. Will there be remote data mirrors, data access, workstations?