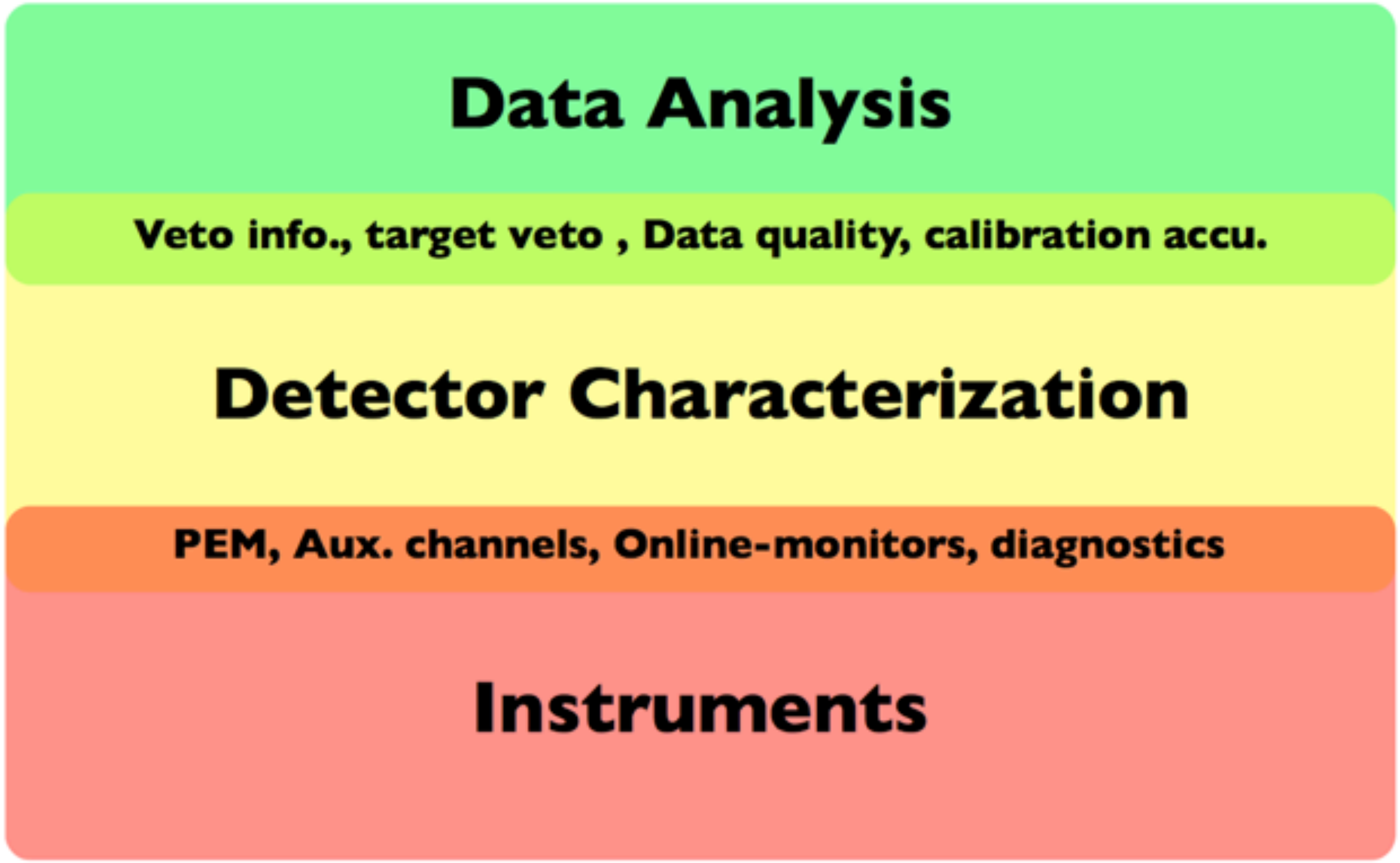
Status of KAGRA Detector Characterization

Kazuhiro Hayama
on behalf of the detector characterization group

Scope of the detector characterization



Two Direction : To provide system, tools for

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

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?

Subsystem detector characterization

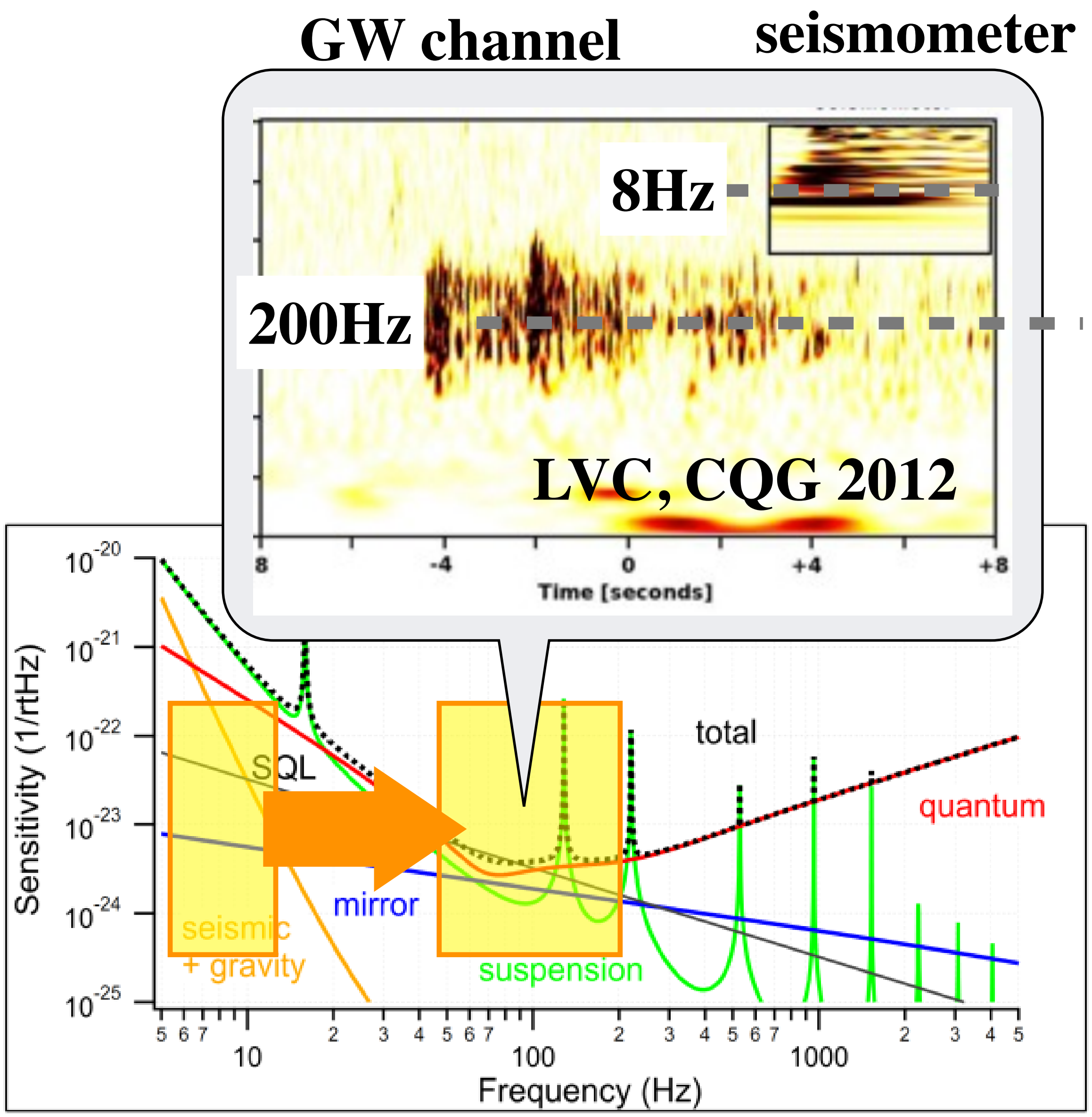
Speed-up commissioning

- 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

Multiple-subsystem characterization

Speed-up commissioning

Example of correlated noise between subsystems



Sensitivity curve of KAGRA

- **Need to watch channels over subsystems**
  - **Up-conversion noise: seismic glitches will excite optical bench motion which cause scattered light noise.**
    -> AOS-VIS channels
- **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

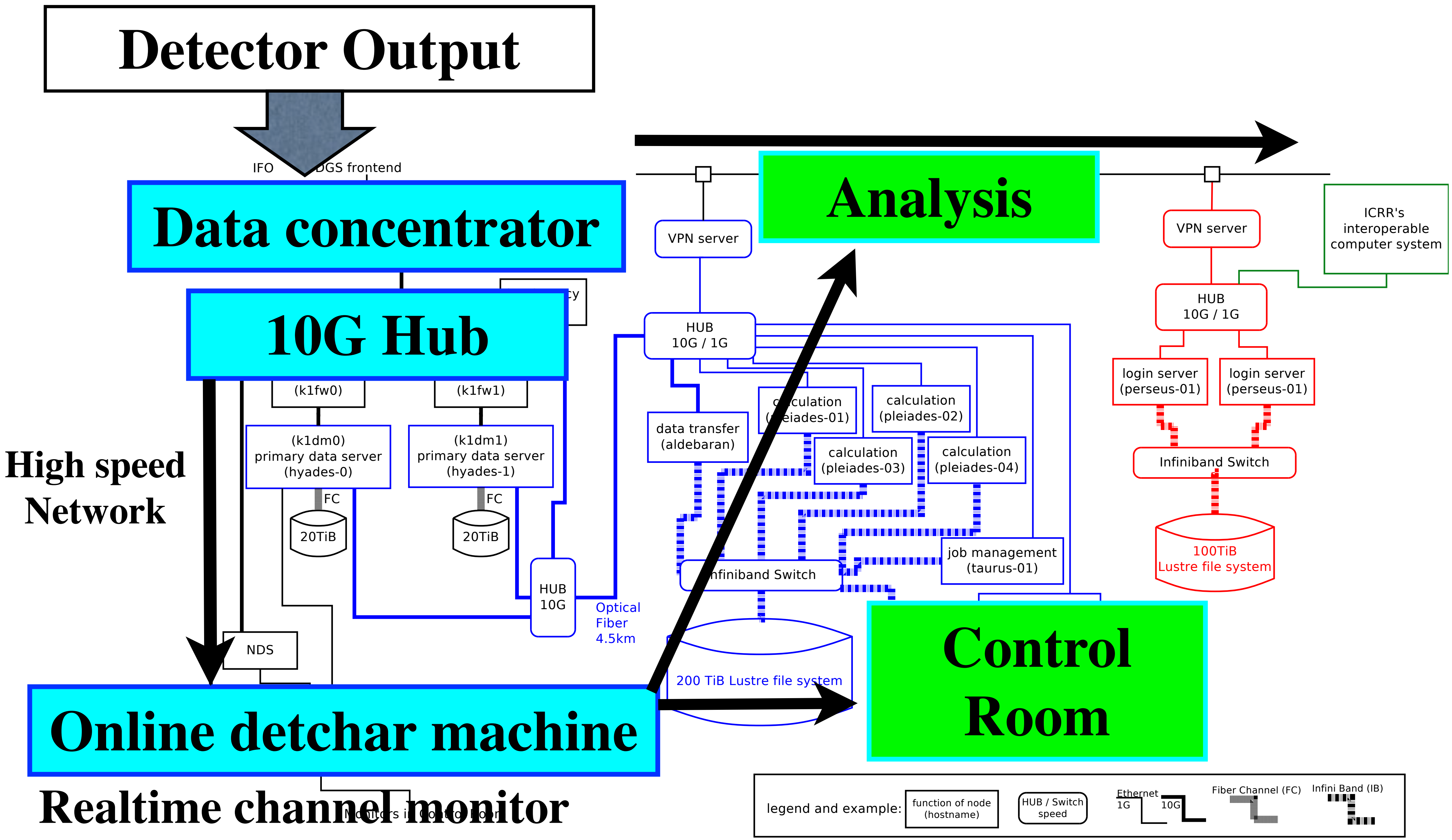
Categorization of data quality

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.

Post processing : Veto Analysis

Veto list generation		
Transient GW (CBC, Burst)	Continuous GW (pulsar, LMXB, …)	Stochastic GW (Early Univ, …)
• Real-time glitch detection • Glitch classification • Coincidence analysis between the GW channel and auxiliary sensor channels. • …	• Line tracking • Line detection • Removal of high frequency spikes • …	• Noise floor monitor • Non-stationary • …

Detector Characterization Cluster



Kanda

14年6月20日金曜日

On going 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

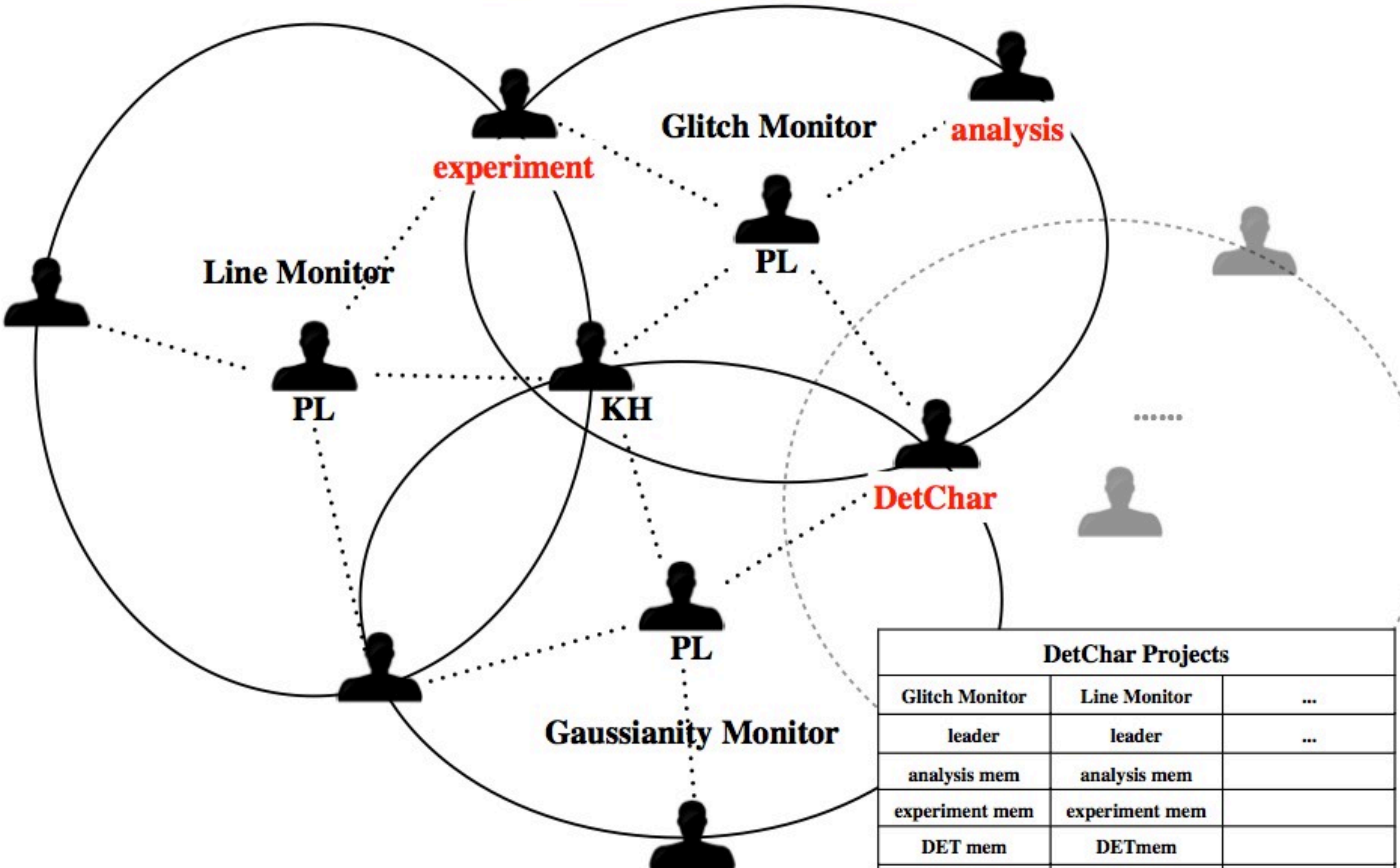
Special Projects

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

● in progress

● in slowly progress

Structure of the projects

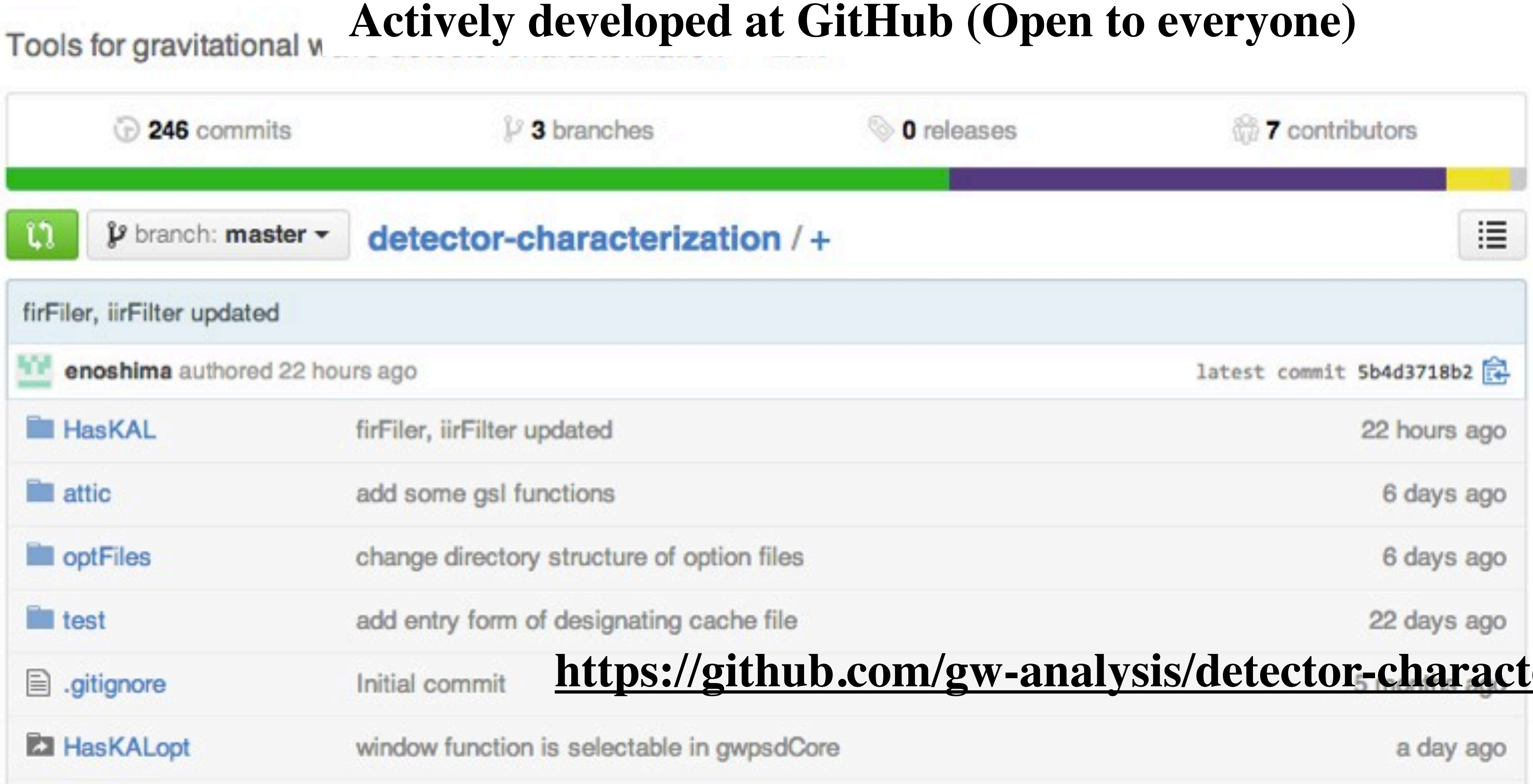


DetChar Projects		
Glitch Monitor	Line Monitor	...
leader	leader	...
analysis mem	analysis mem	
experiment mem	experiment mem	
DET mem	DETmem	

HasKAL : DetChar tools/system

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

Actively developed at GitHub (Open to everyone)



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

Structure of HasKAL

branch: **master** ▾ detector-characterization / HasKAL / src / **HasKAL** / +

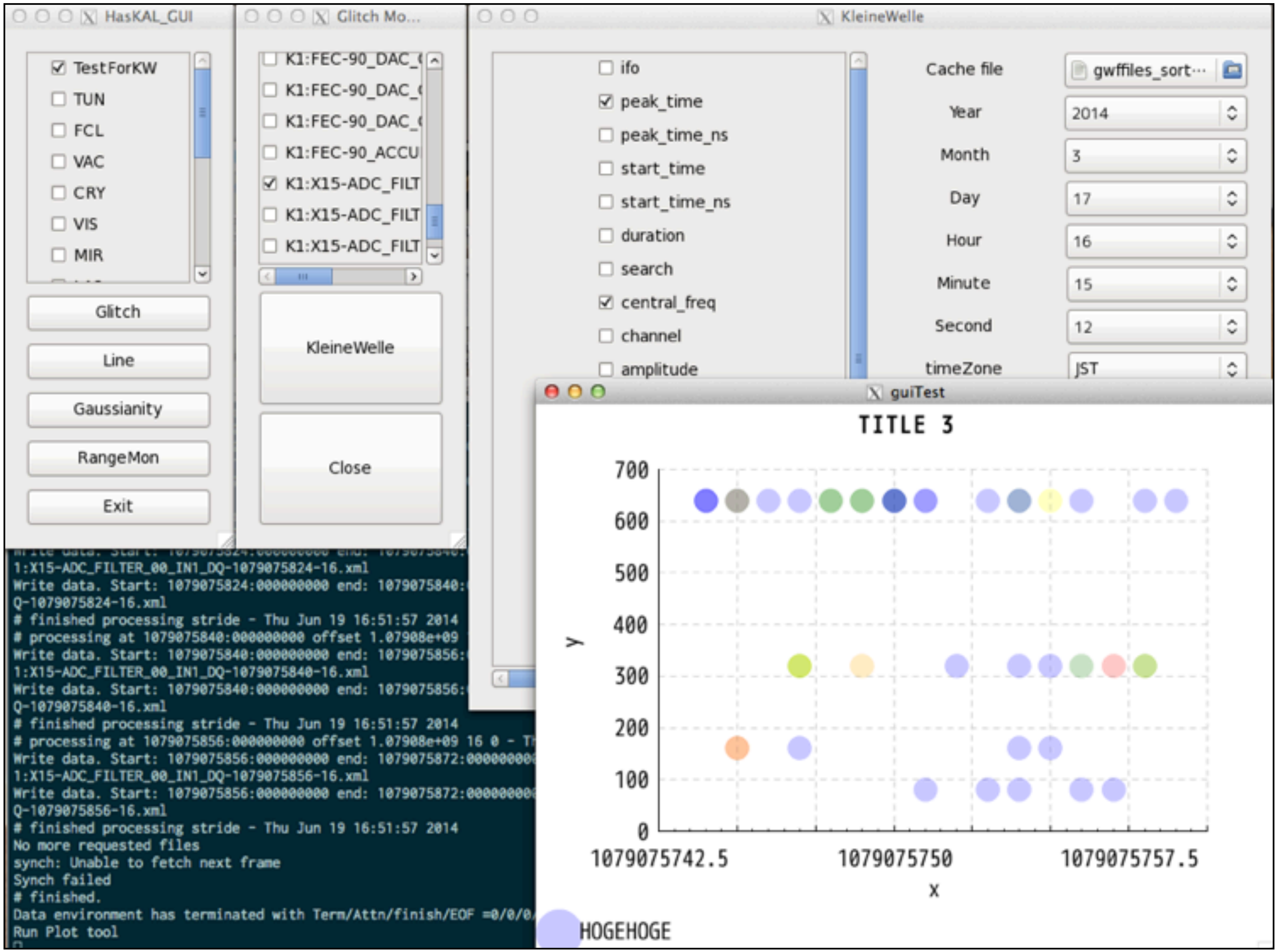
firFiler, iirFilter updated

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

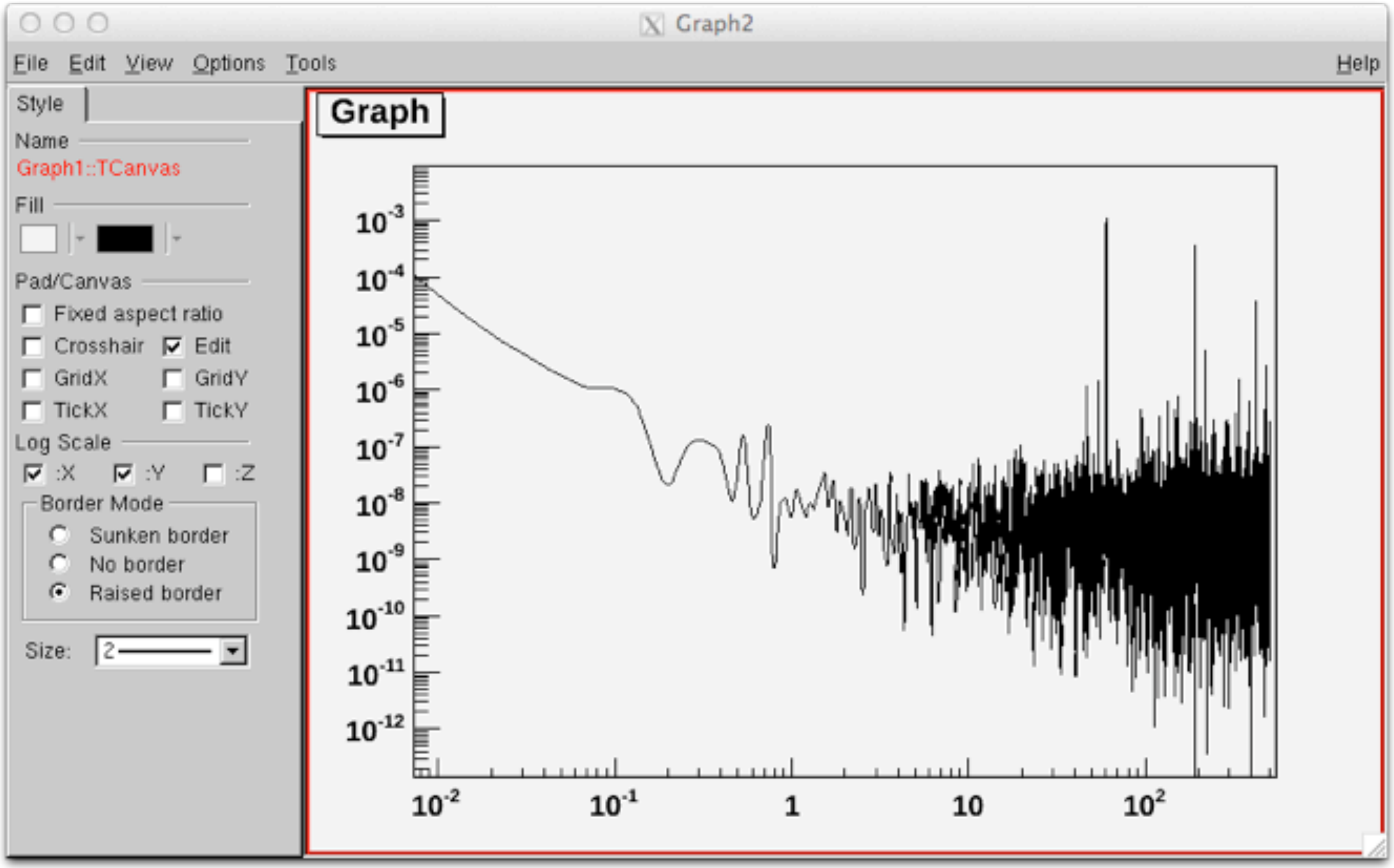
DetChar GUI

Running Glitch Monitor (kleineWelle)



Yamamoto

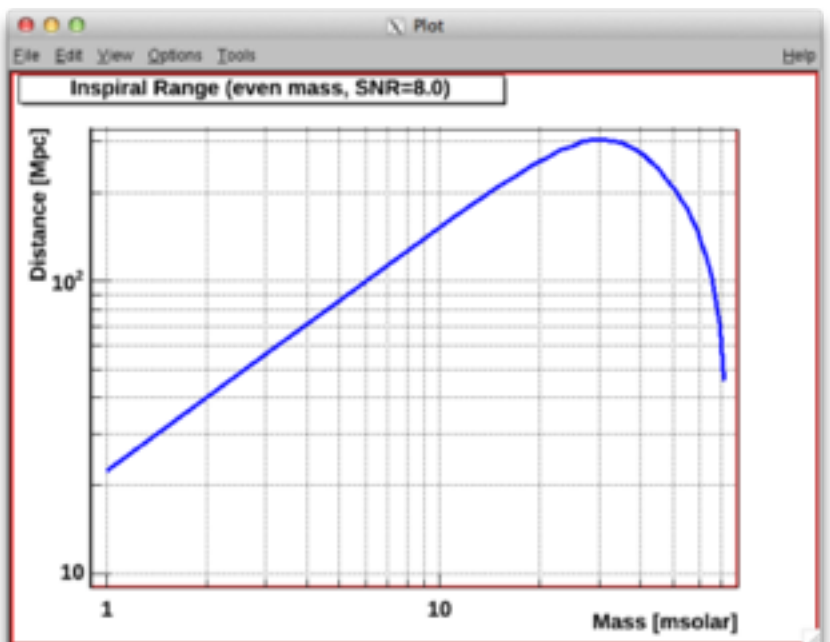
ROOT based plotting



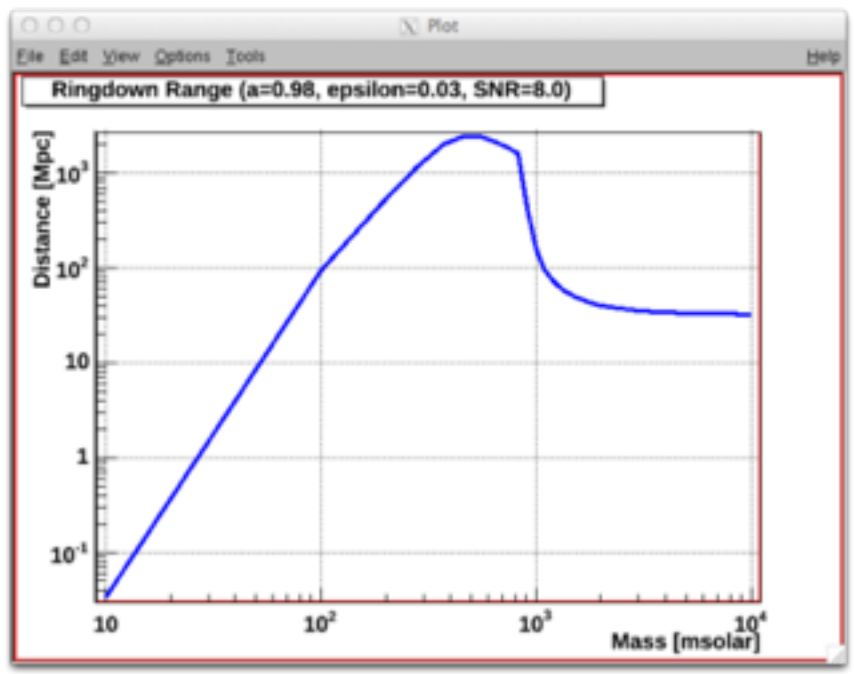
Yuzurihara

Range Monitor

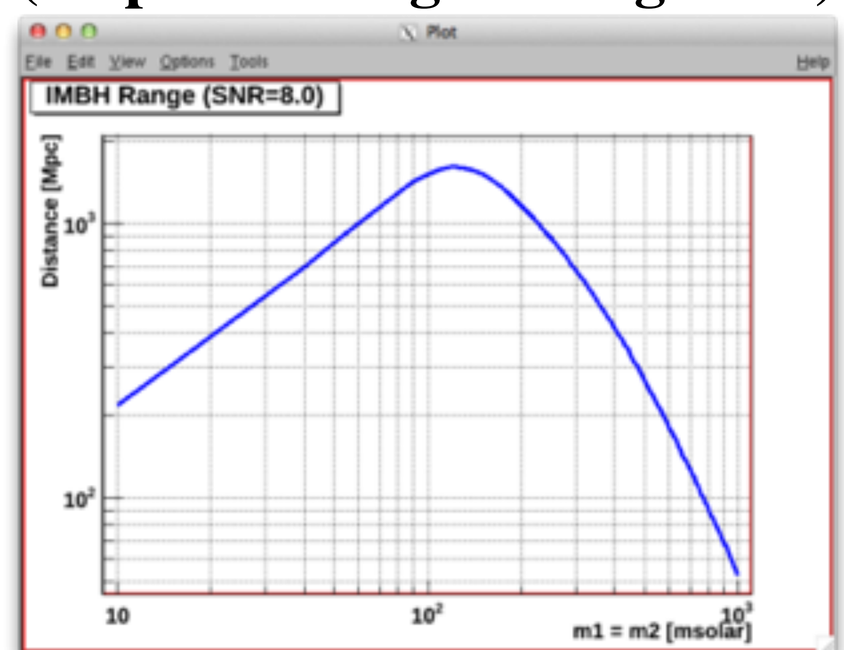
Inspiral



Ringdown



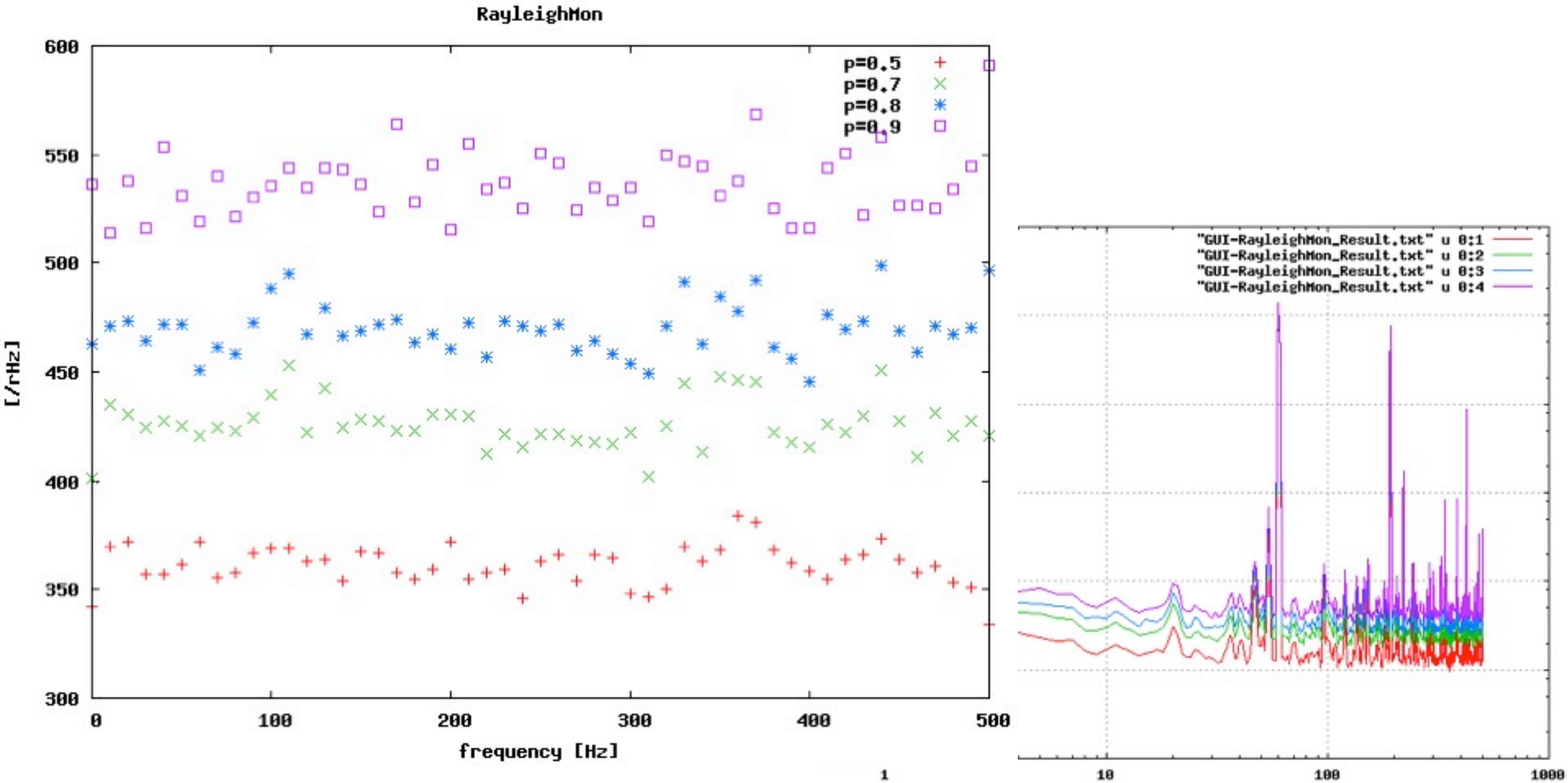
IMBH (Inspiral+Merger+Ringdown)



Ono, Hayama

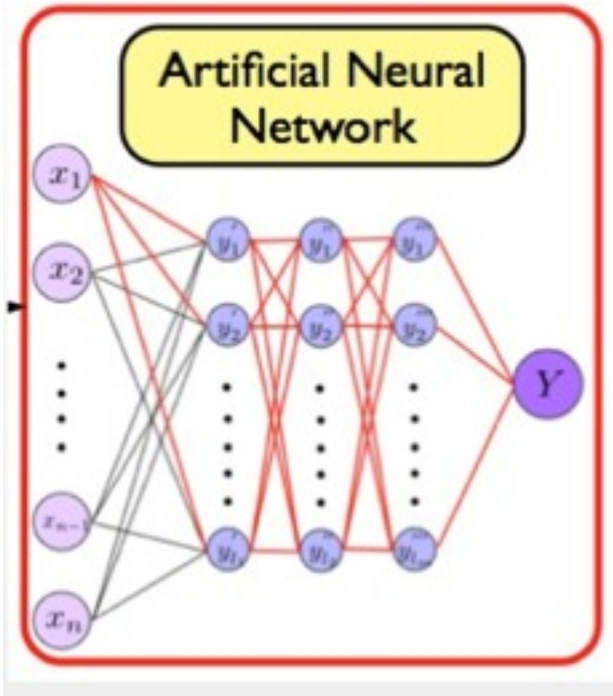
Rayleigh Monitor

- Investigating noise behavior at various frequency regions



Yamamoto

Multi-Channel Analysis

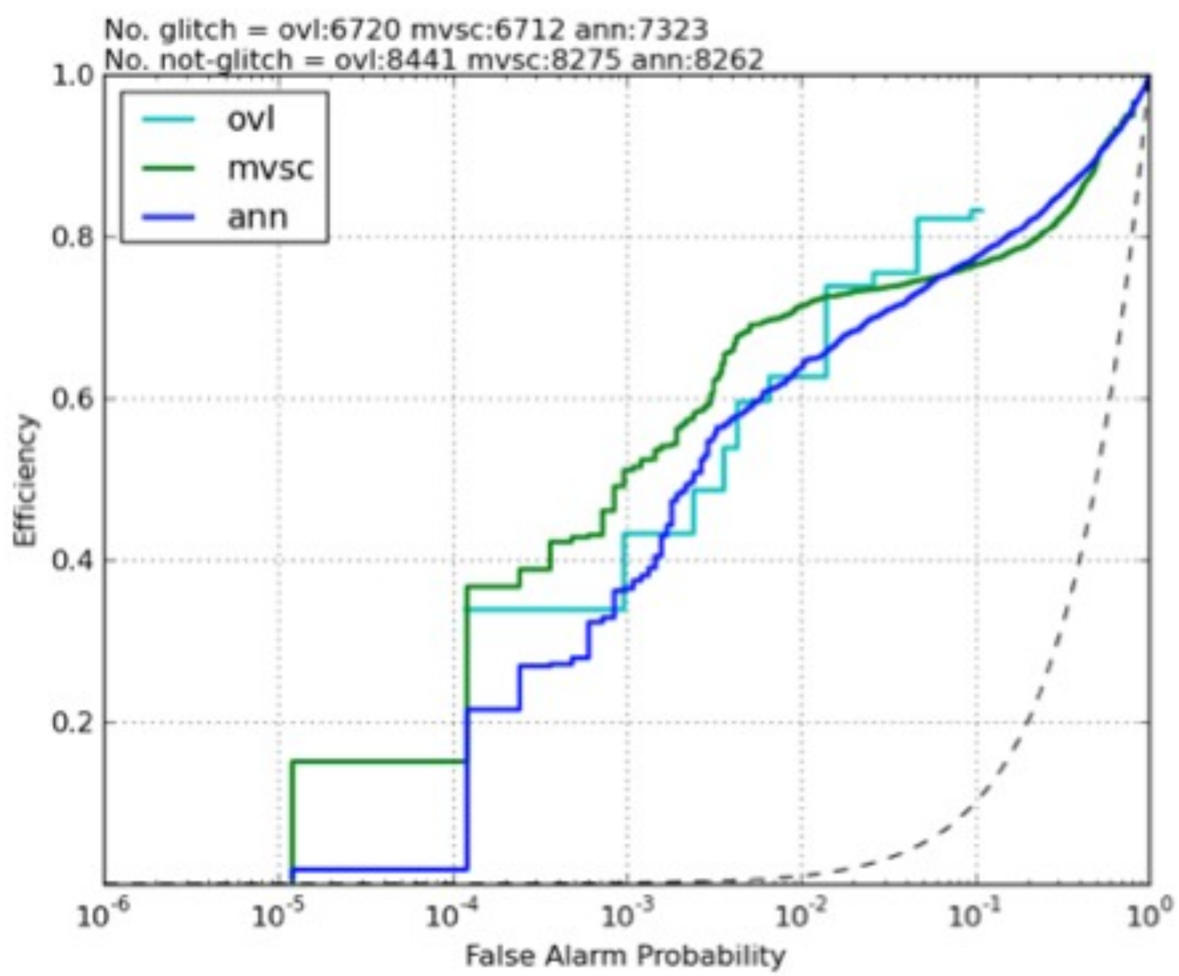


- **Work with Korean GW group**
- **Initial Goal:**
  - **Development of a method for localize noise sources using auxiliary channels and PEMs to support find/kill noise sources.**
  - **KGWG has been developing ANN based one for post-processing analysis in LVC.**
  - **We focuses on a tool useful for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

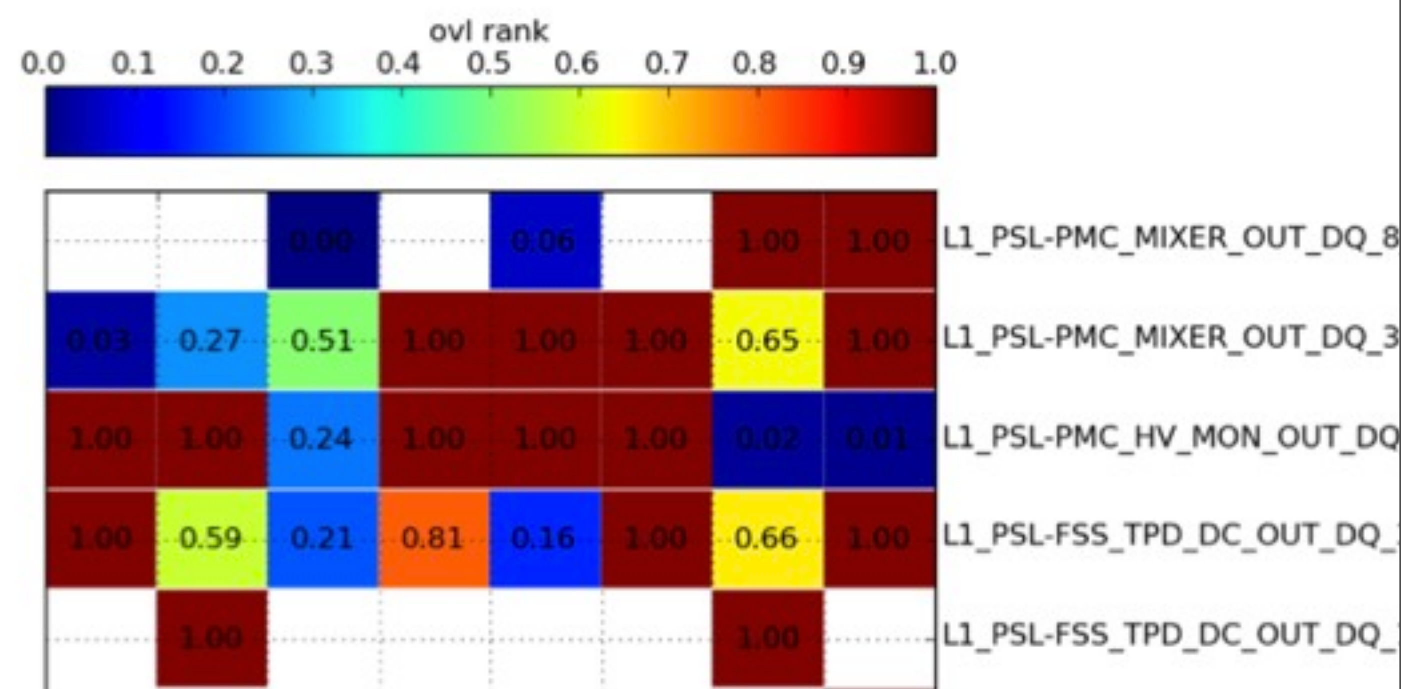
Integrating iDQ into HasKAL

- 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

Reciever Operating Characteristic Curve



Channel performance trends



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

Data quality study

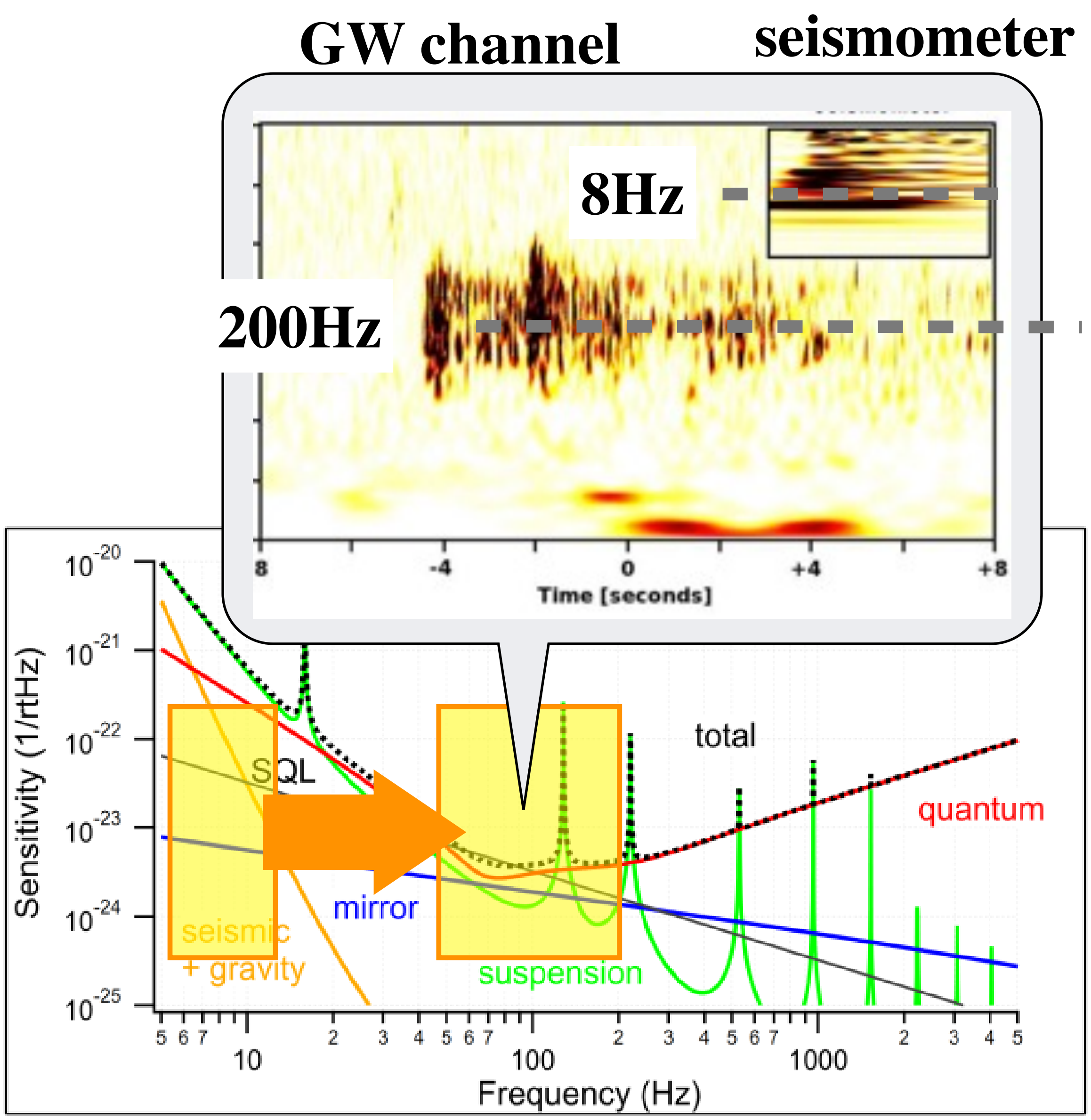
Daisuke Tatsumi (NAOJ)

Reduction of cryogenic induced glitches
KAGRA is a unique cryogenic detector in the world.
We are developing 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

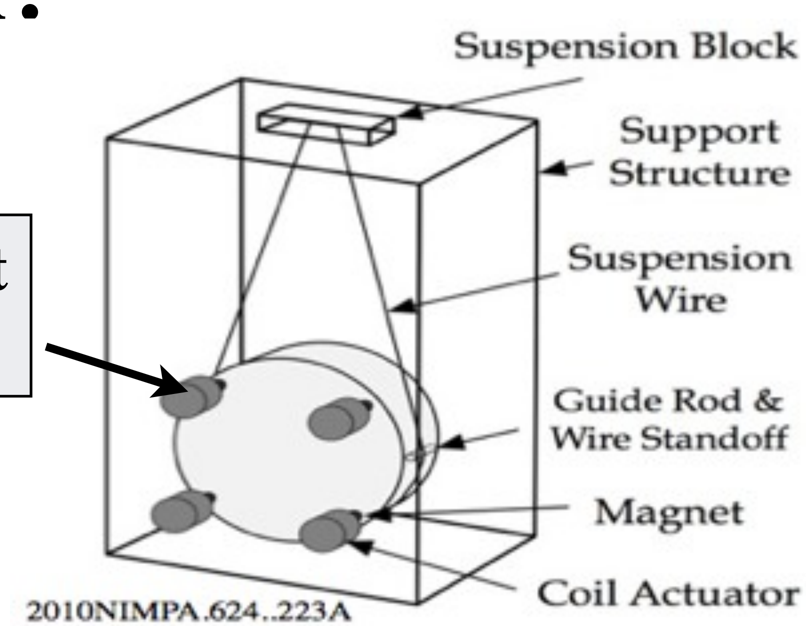
What about Seismic Up-Conversion Noise ?



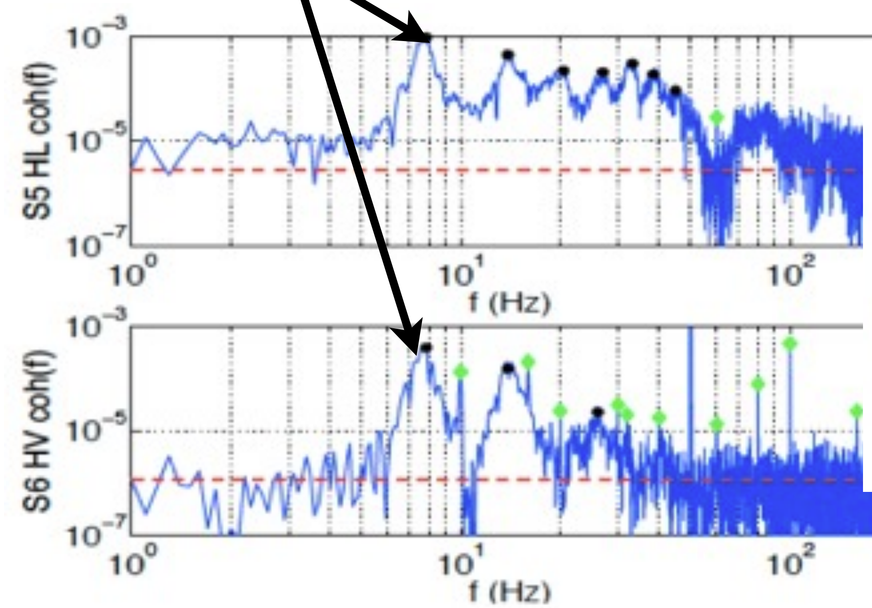
Sensitivity curve of KAGRA

How magnetic field affects KAGRA?

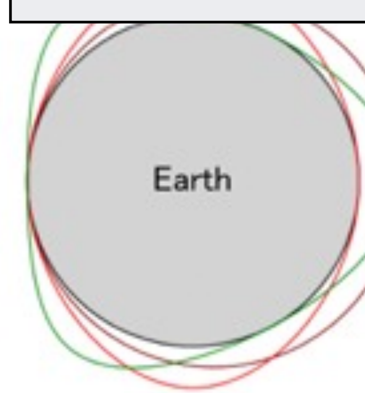
Coil-Magnet Actuator



Globally correlated noise



Schumann resonance

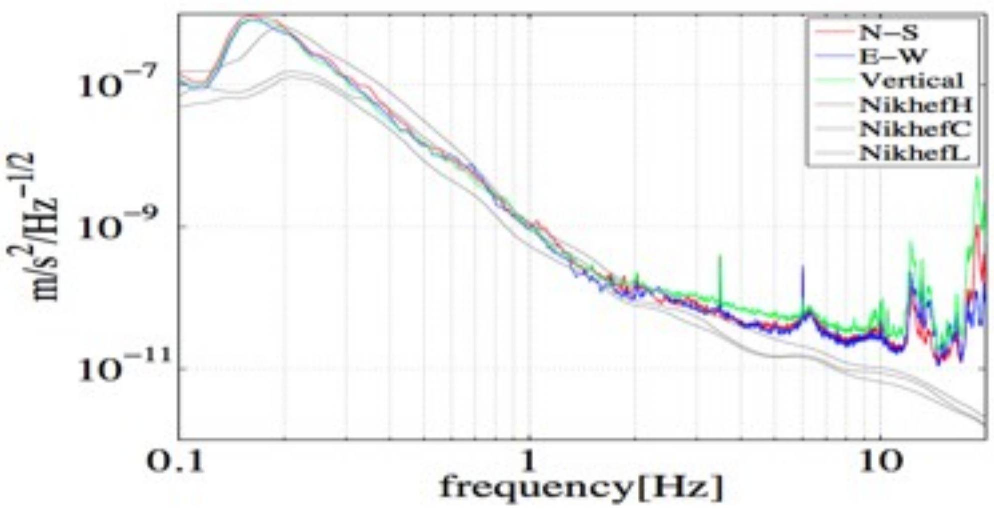


Location of the measurement

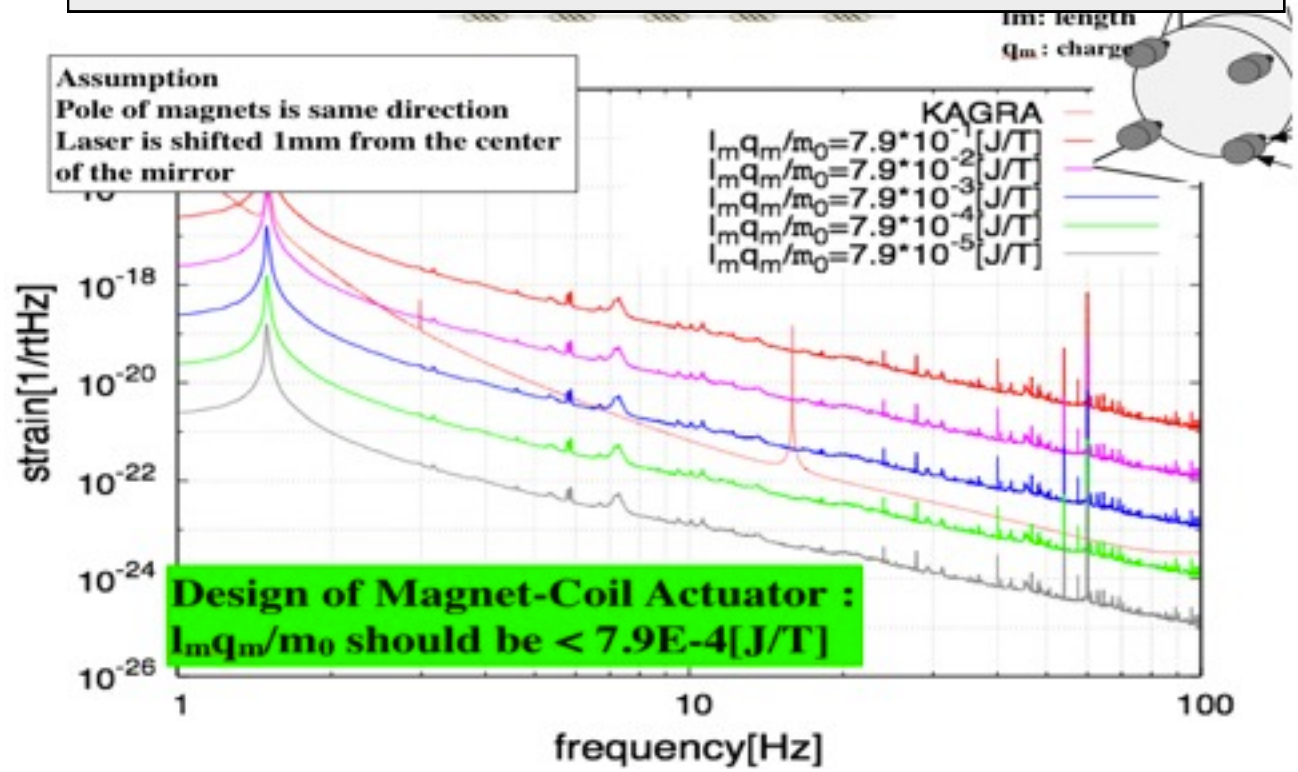
Measurement at the KAGRA site

Seismic noise : < 2Hz consistent with CLIO

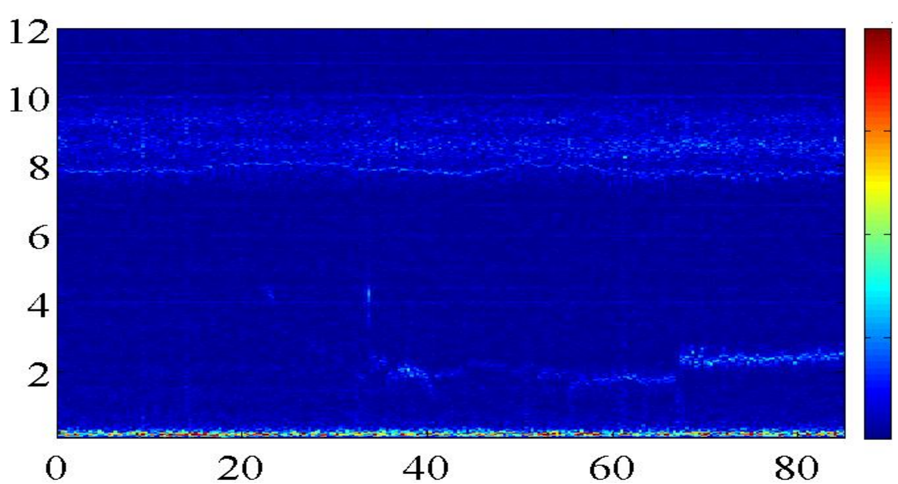
high frequency under investigation



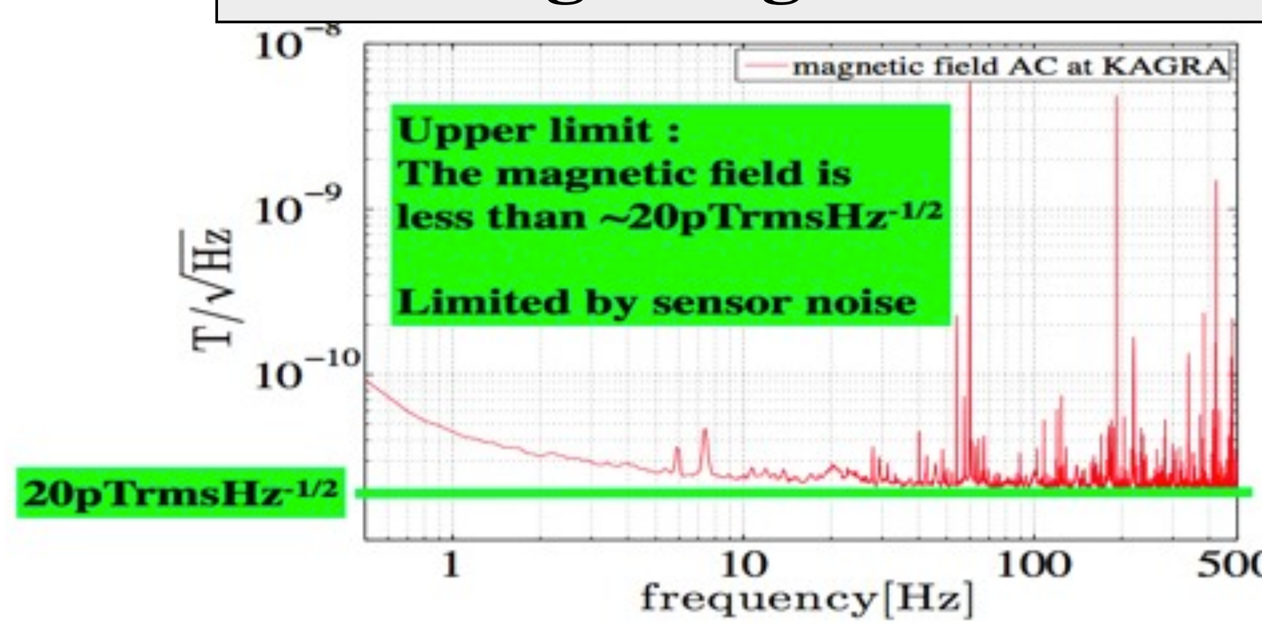
magnetic field :Requirement of Coil-magnet actuator



Stationarity:not bad, but longer data needed



No strange magnetic sources



S : Globally Correlated Magnetic Noise

Atsushi Nishizawa
Kyoto Univ.

Global correlated magnetic noise

- Schumann resonance
  Resonance of the ionosphere due to discharge of thunders, solar wind,...
  - very weak (0.5-1E-12T/rHz) (Earth's:1E-5T)

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

Influence on SGWB search

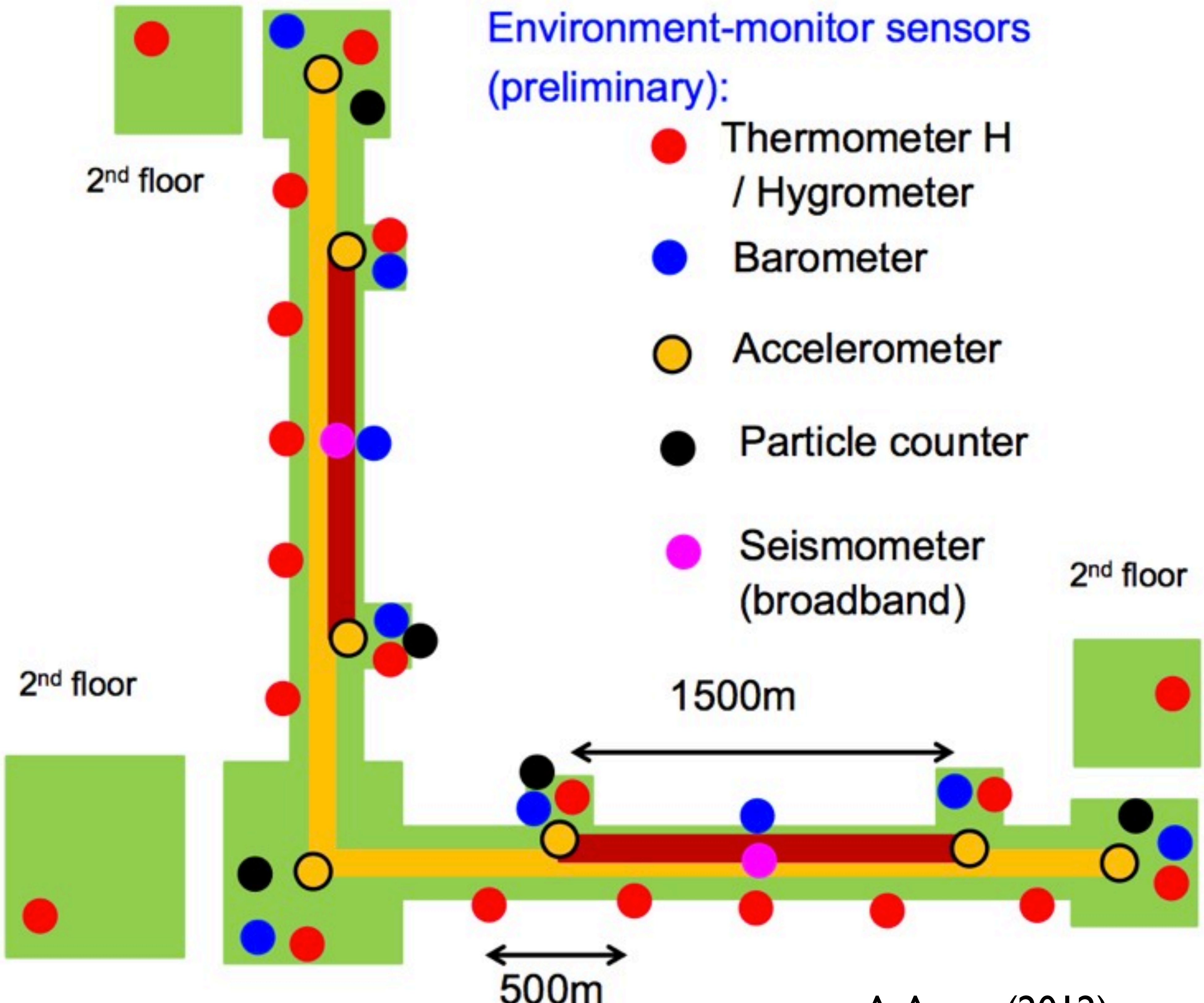
detector pair	$h_0^2\Omega_{gw}$ w/o magnetic noise	$h_0^2\Omega_{gw}$ w/ magnetic noise	degradation factor
HL	5.5×10^{-9}	2.5×10^{-8}	4.55
HV	2.4×10^{-8}	4.1×10^{-8}	1.71
LV	2.0×10^{-8}	3.5×10^{-8}	1.75
KH	3.8×10^{-8}	5.0×10^{-8}	1.31
KL	6.4×10^{-8}	7.7×10^{-8}	1.20
KV	2.2×10^{-8}	3.4×10^{-8}	1.54

表 1: Detectable $h_0^2\Omega_{gw}$ 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.

Schedule

- ☑ 2014 June : Installation of detchar GUI on VIS digital system at NAOJ so that VIS people use the GUI and feed back to us
- ☐ 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



A. Araya (2012)

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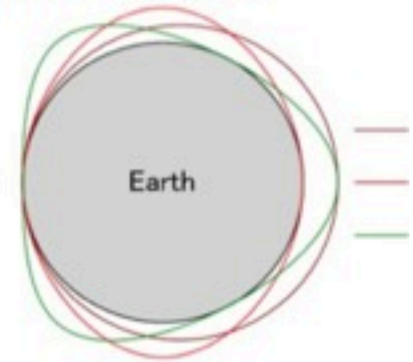
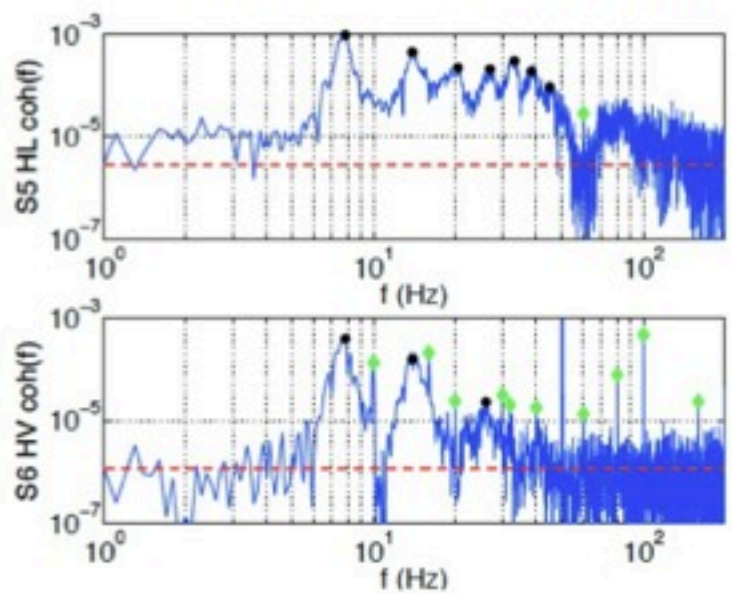
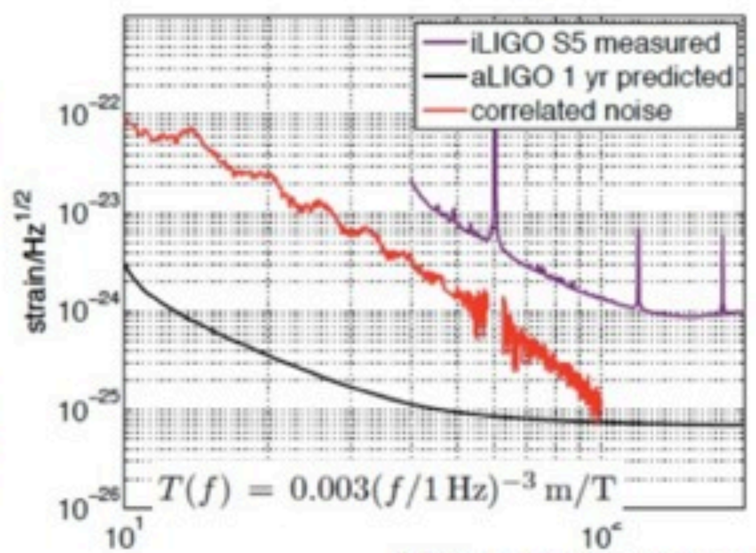
- Schumann resonance
  Resonance of the ionosphere due to discharge of thunders, solar wind,...
  - very weak (0.5-1E-12T/rHz) (Earth's:1E-5T)
  - Long coherent length ~1000km
  - Correlation shows up by 1year integration







E. Thane et al. 2013

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