

# **Status of KAGRA Detector Characterization**

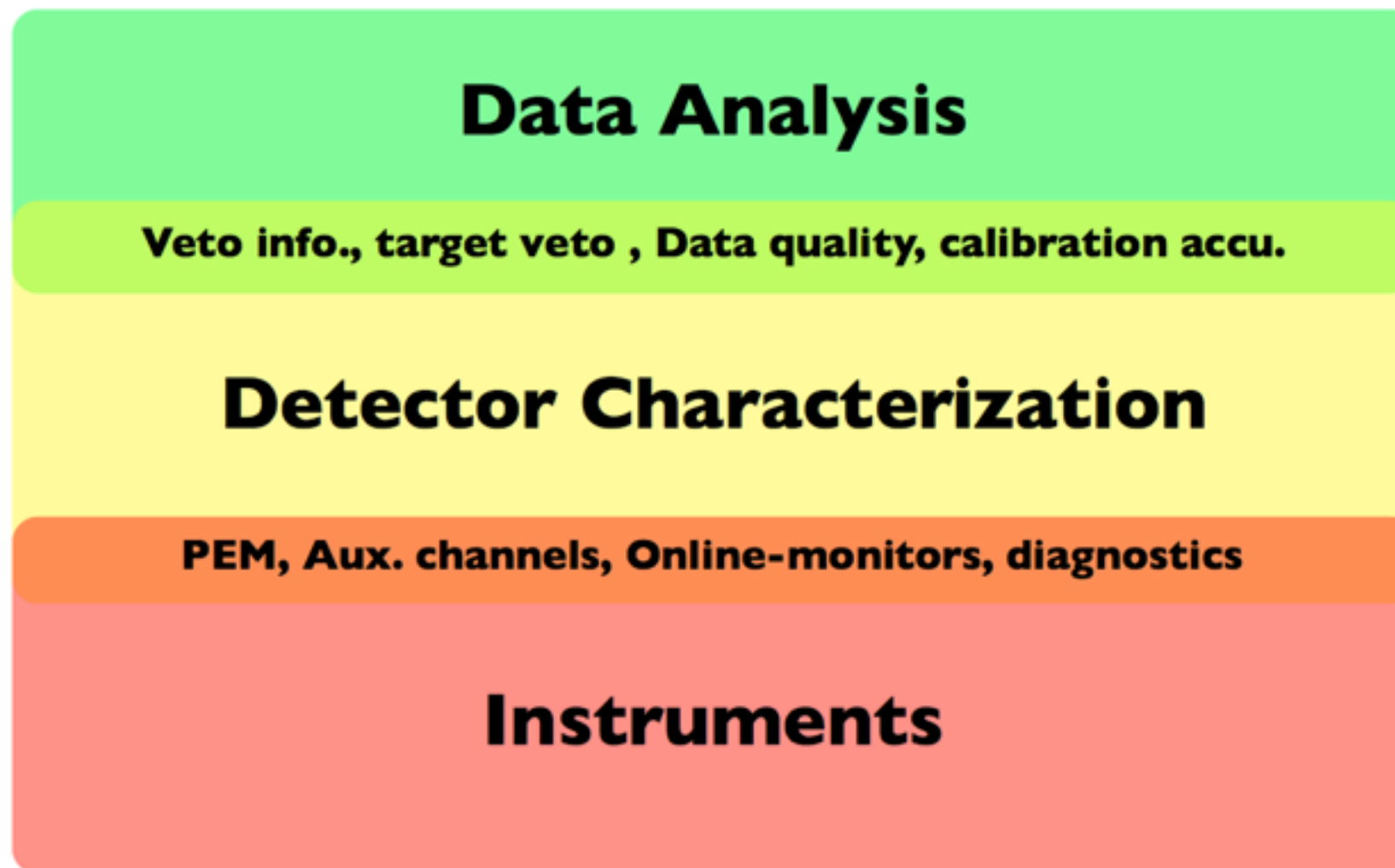
**Kazuhiro Hayama  
on behalf of detector characterization group**

# Human Resources



- **Kazuhiro Hayama**
- **Asano, Itoh, Mano, Ono, Yamamoto, Yokozawa, Yuzurihara, Narikawa, Ueno, Kanda, and so on**
- **John Oh, SangHong Oh, Young-Ming Kim, Edwin Son (KGWG)**
- **Keiko Kokeyama (LIGO)**
- **Didier Verkindt (Virgo)**

# Interface of the detector characterization



**Two Direction : To provide system, tools for**

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



# Subsystem detector characterization

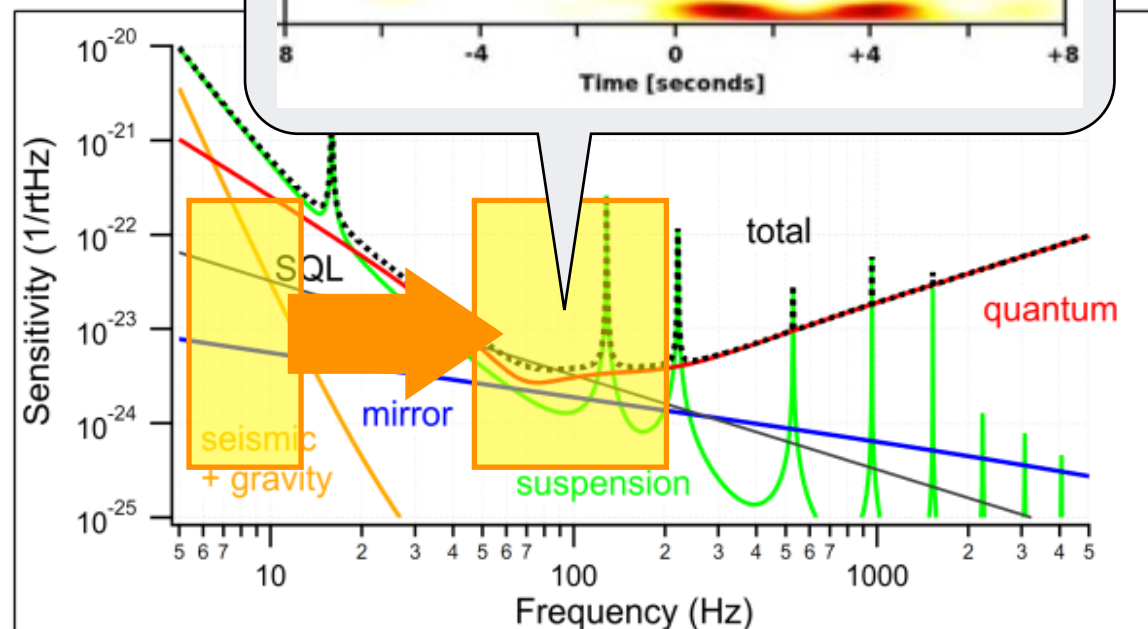
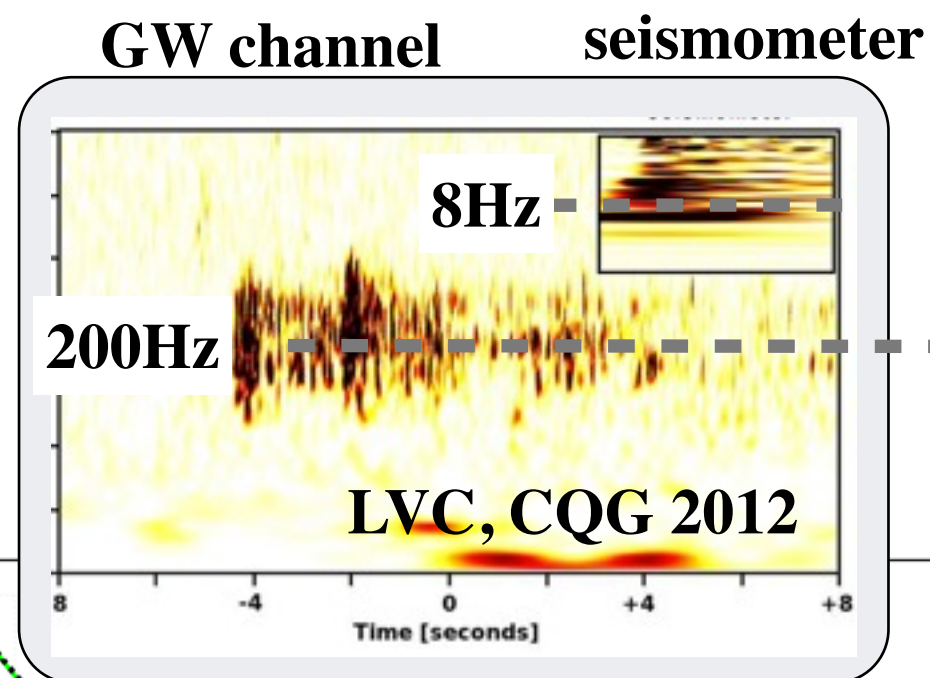
## Speed-up commissioning

- **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



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
- **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

## 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"> <li>• Real-time glitch detection</li> <li>• Glitch classification</li> <li>• Coincidence analysis between the GW channel and auxiliary sensor channels.</li> <li>• ...</li> </ul>	<ul style="list-style-type: none"> <li>• Line tracking</li> <li>• Line detection</li> <li>• Removal of high frequency spikes</li> <li>• ...</li> </ul>	<ul style="list-style-type: none"> <li>• Noise floor monitor</li> <li>• Non-stationary</li> <li>• ...</li> </ul>

# DetChar Tools



- Software developed on GitHub, free, no maintenance is needed. We can concentrate into development.
- Progress is reported in detchar blog

<http://gwclio.icrr.u-tokyo.ac.jp/lcgsubgroup/detectorcharacterization/>

**15 commits per a week**

The screenshot shows the GitHub interface for the repository 'detector-characterization'. At the top, a summary bar displays '365 commits' (circled in red), '3 branches', '0 releases', and '8 contributors'. Below this, the 'branch: master' is selected. The commit history table lists recent changes:

Commit Message	Author	Time
added test code to perform permutation test in haskell	enoshima	22 hours ago
rename files	HasKAL	22 hours ago
added test code to perform permutation test in haskell	attic	22 hours ago
add test code for student rayleighMon	optFiles	17 days ago
test (Asano)	test	9 days ago
Initial commit	.gitignore	6 months ago
window function is selectable in gwpsdCore	HasKALopt	a month ago

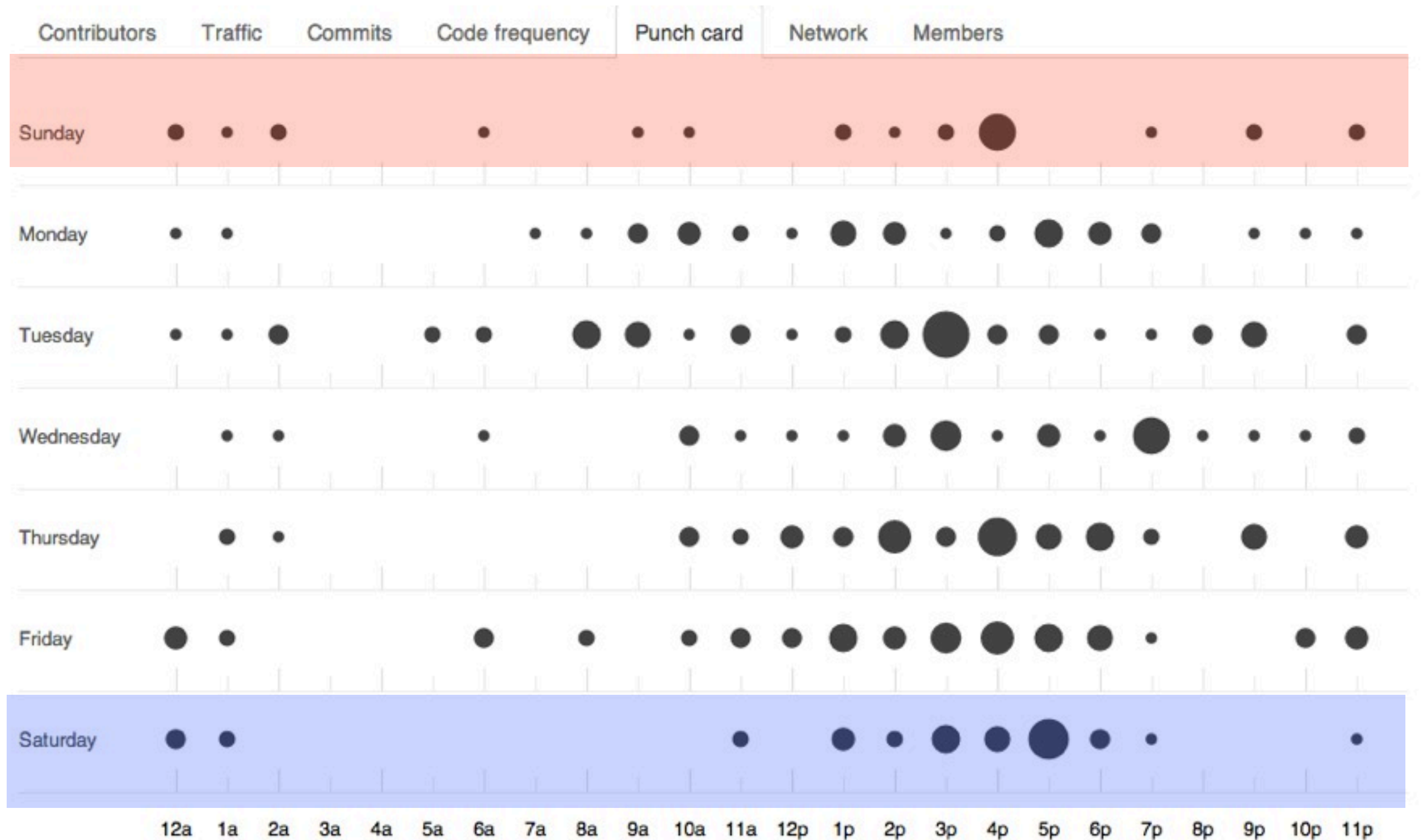
<https://github.com/gw-analysis/detector-characterization>



# Weekly Activities



- Circle shows volume of commits



1am

10am

5pm

11pm

# Structure of HasKAL



DetectorUtils	fix bug in Detector module
ExternalUtils	change module name
FrameUtils	change Type of the sampling frequency, Double. change the local funct...
GUI_Utils	add FitMethod type for SRMon
Misc	add module of flip for 3 parameters
MonitorUtils	modify bug of StochMon
PlotUtils	add plotSaveAsPicture function in module
SignalProcessingUtils	reduced input number of filter functions
SimulationUtils	<a href="#">move DetectorNoiseGenerator.hs</a>
SpectrumUtils	move DetectorNoiseGenerator.hs
StatisticsUtils	rename files
TimeUtils	make gps2timetuple by yokozawa

<https://github.com/gw-analysis/detector-characterization/tree/master/HasKAL/src/HasKAL>

# DetChar projects

## Primary Projects

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

## Special Projects

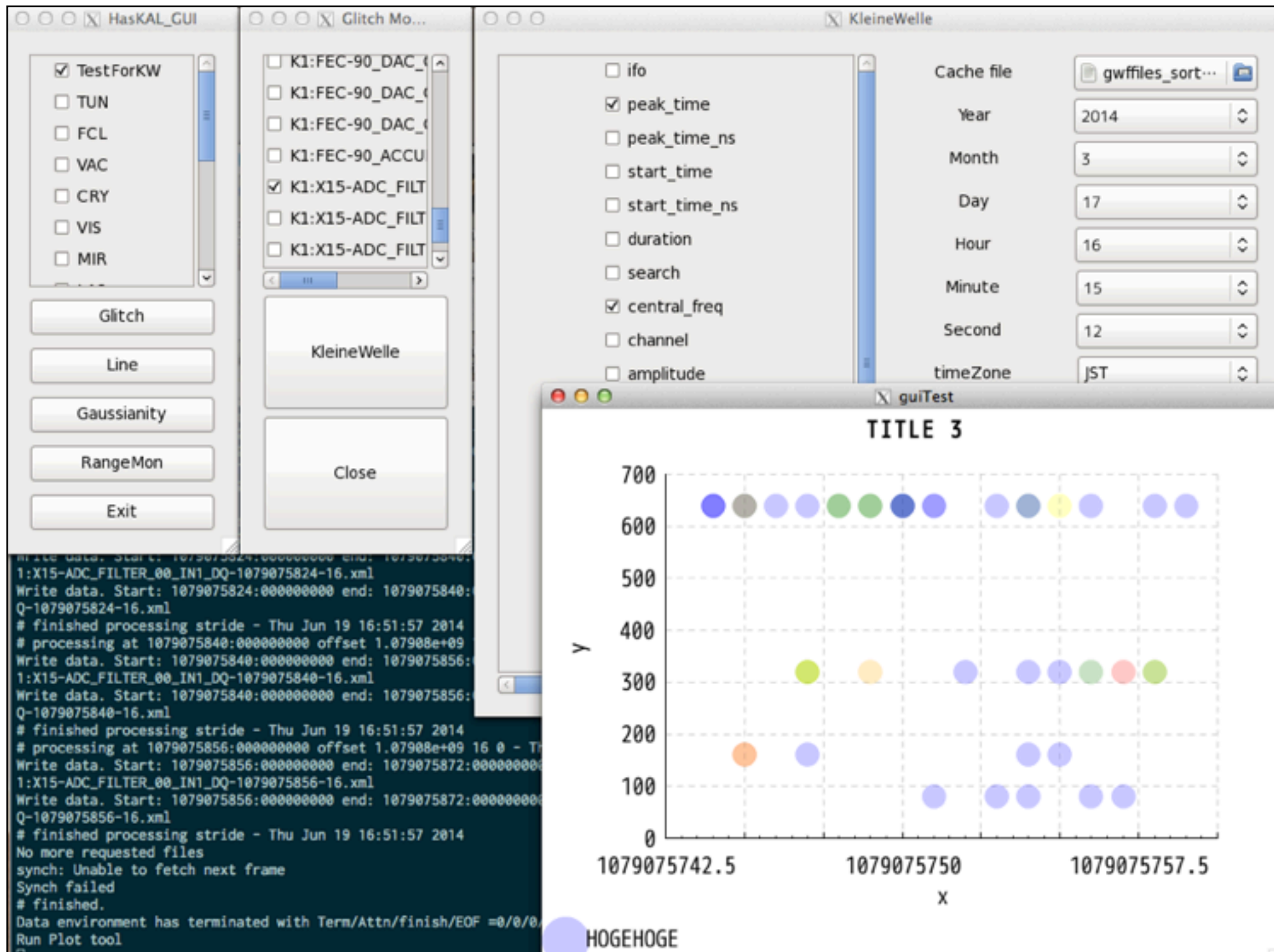
- ☒ Globally correlated mag noise
- ☒ Violin mode
- ☒ Multi-Channel Analysis  
(with Korea detchar, Mano)
- ☐ Detchar shift plan
- ☐ Newtonian Noise
  - ☒ in progress
  - ☐ in slowly progress

## Noise Characterization at the KAGRA site



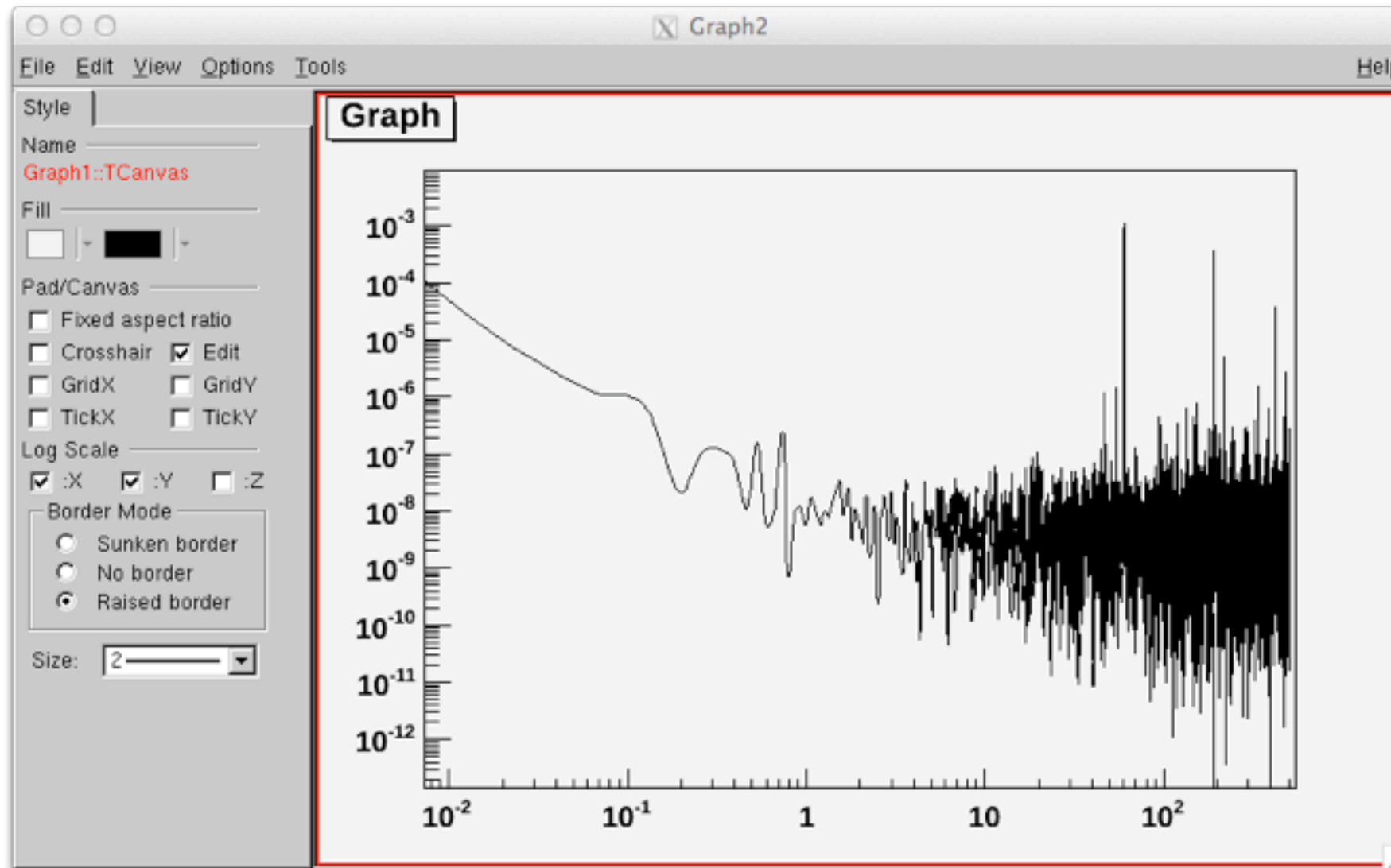
# DetChar GUI

## Running Glitch Monitor (kleineWelle)



Yamamoto+

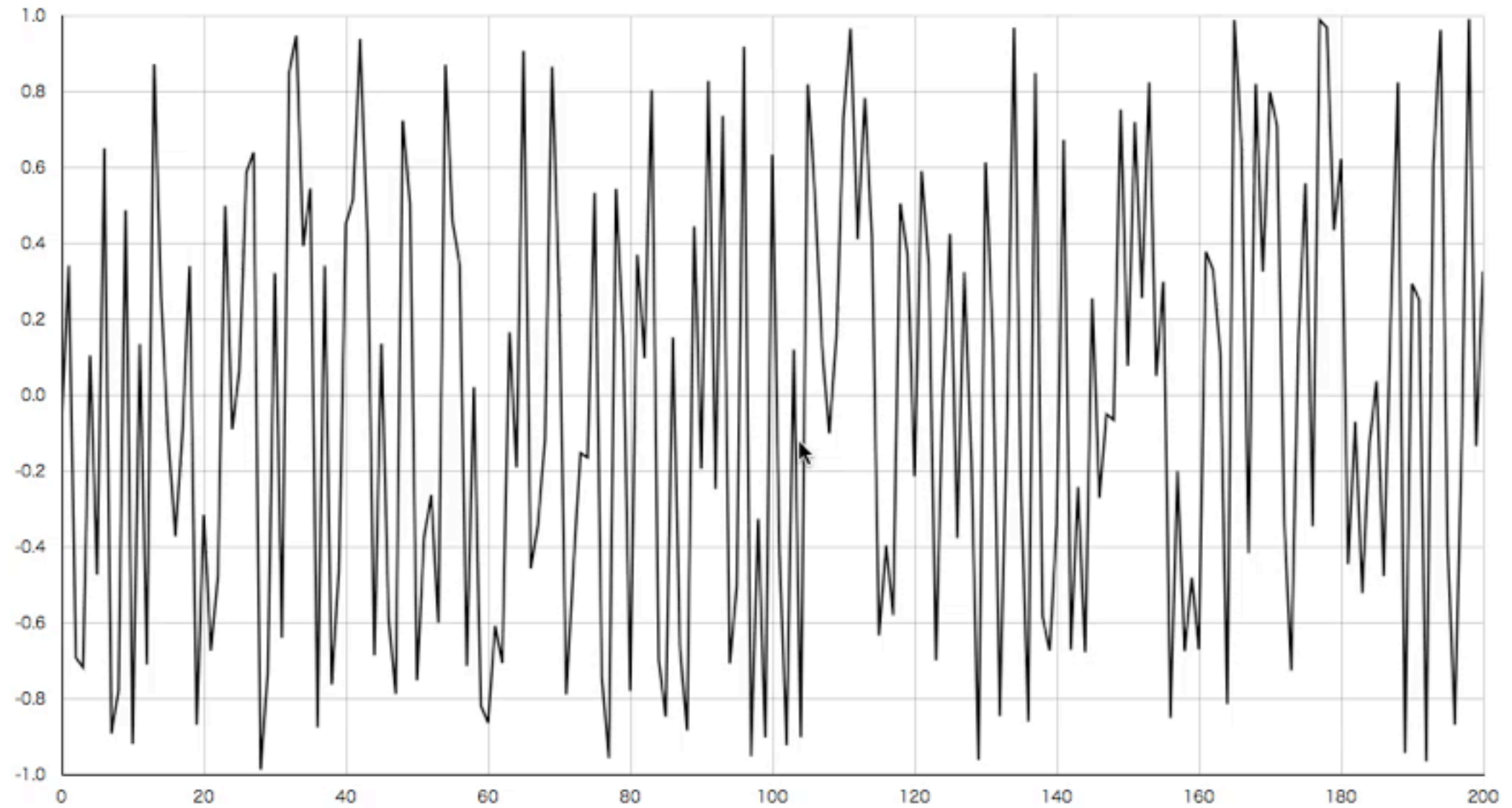
# ROOT based plotting



Yuzurihara



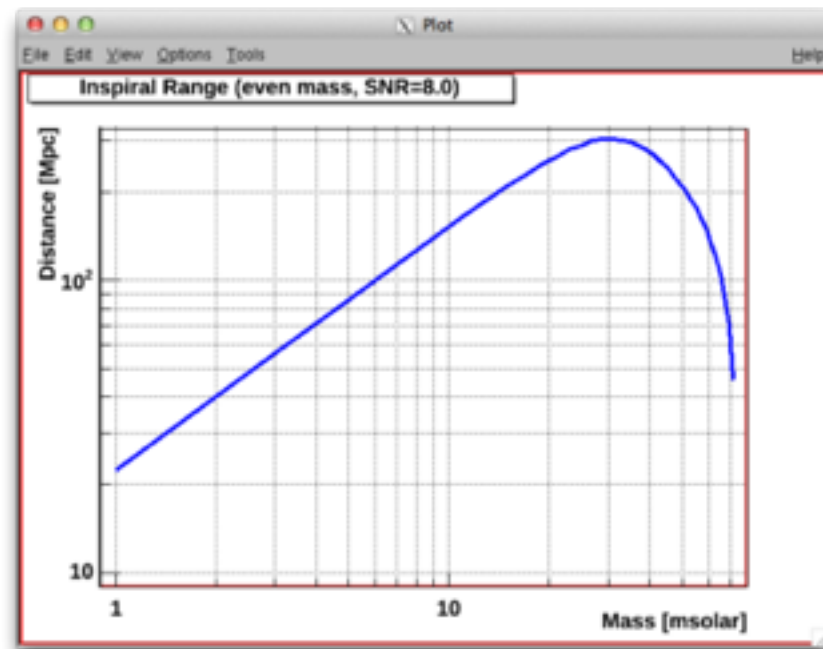
# Dynamical Plotting Tools



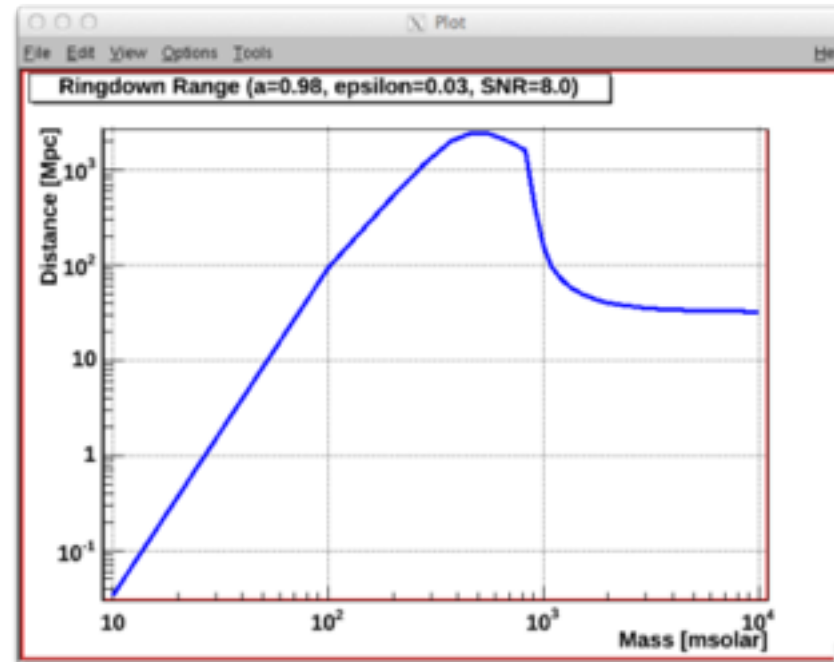
# Range Monitor

## Characterizing telescope sensitivities

### Inspiral



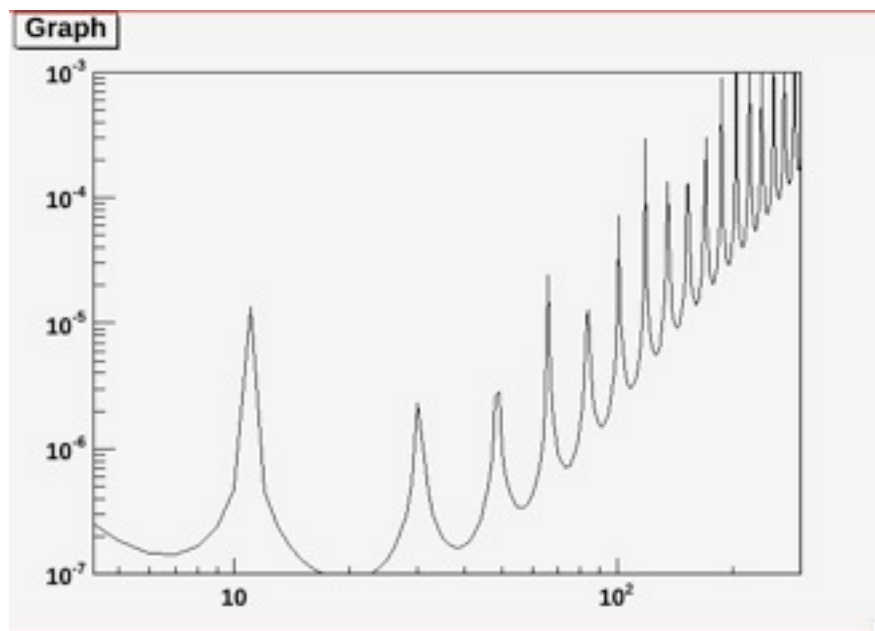
### Ringdown



### IMBH (Inspiral+Merger+Ringdown)



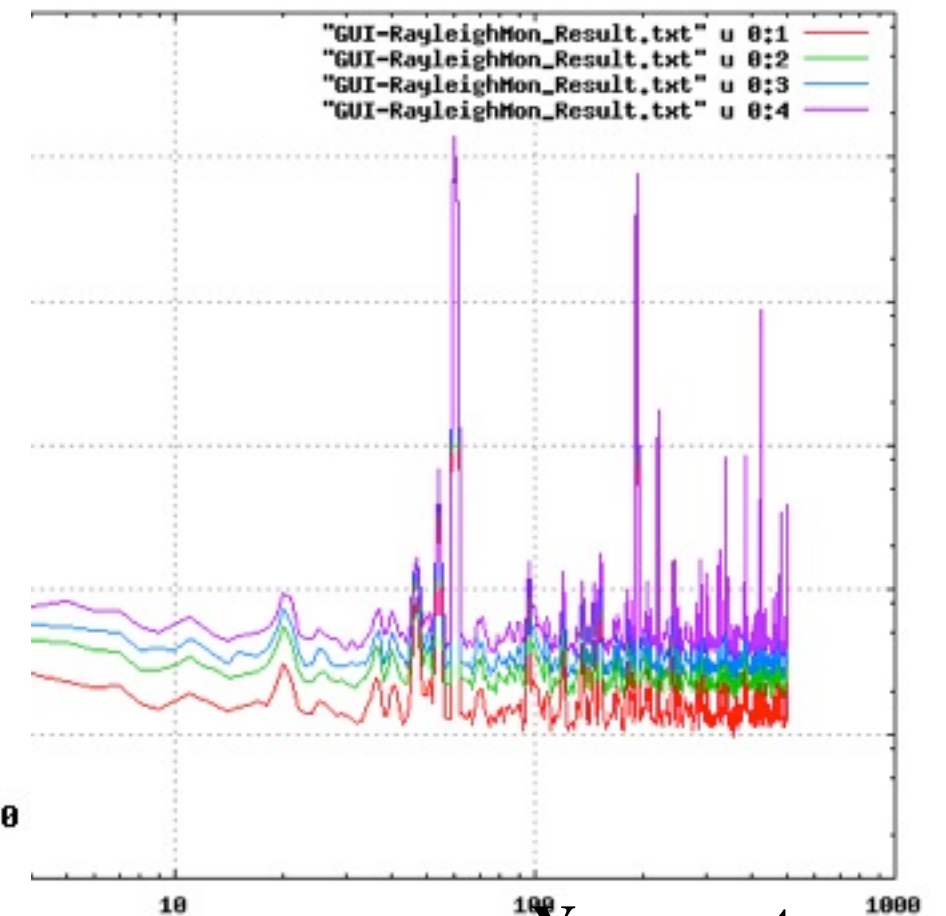
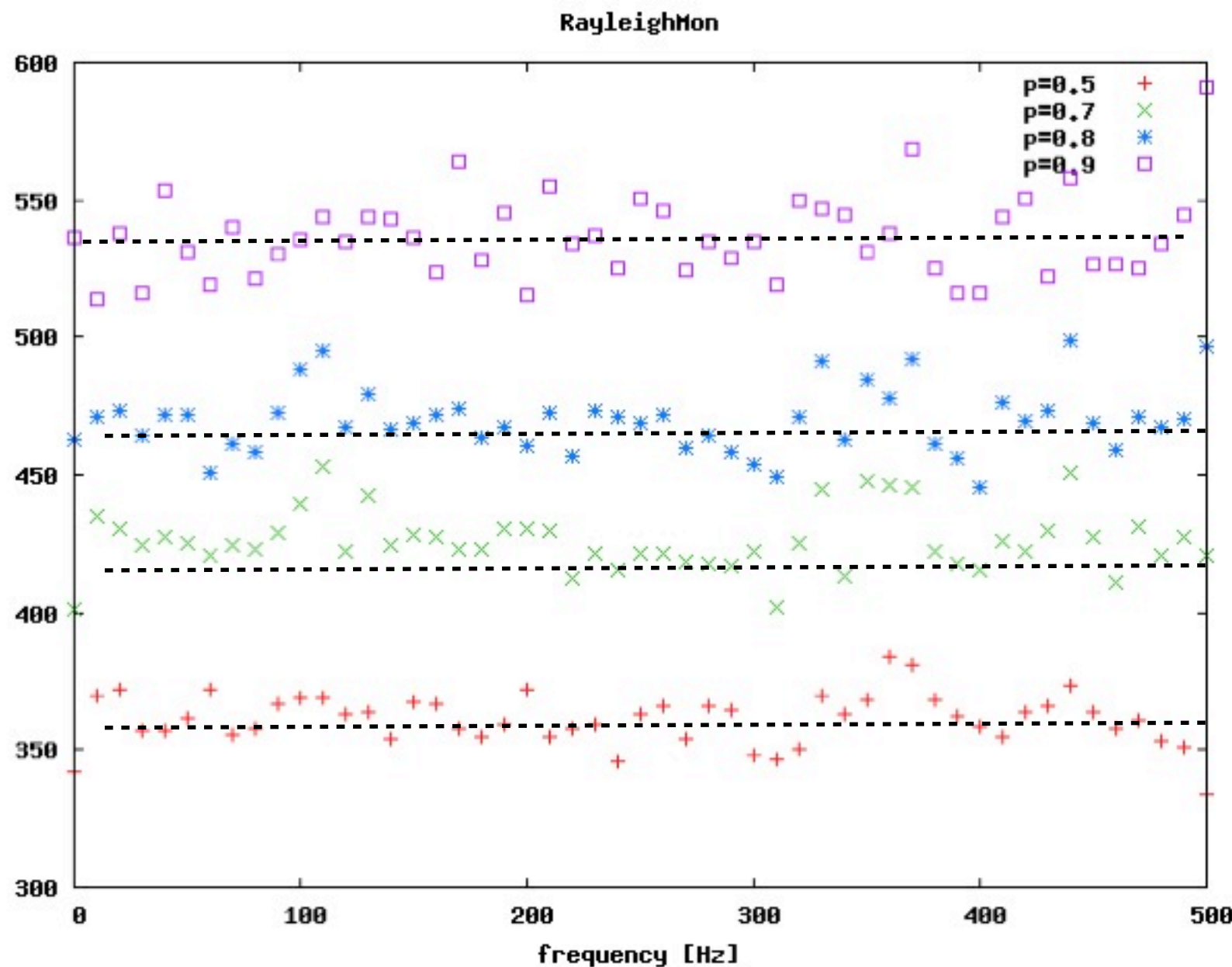
### Stochastic



Ono, Hayama, Yokozawa

# Rayleigh Monitor

## Investigating noise behavior at various frequency regions



Yamamoto

# Correlation Analysis



- Finding both linear and **nonlinear** correlations between channels and infer such as up-conversion noise which are not found/understood.

○

	ch1	ch2	ch3	ch4	ch5	ch6
ch1	1.00	-0.41	-0.51	0.75	0.80	-0.75
ch2	-0.41	1.00	0.05	-0.46	-0.57	0.42
ch3	-0.51	0.05	1.00	-0.33	-0.35	0.34
ch4	0.75	-0.46	-0.33	1.00	0.82	-0.98
ch5	0.80	-0.57	-0.36	0.82	1.00	-0.82
ch6	-0.75	0.43	0.34	-0.98	-0.82	1.00

Yuzurihara

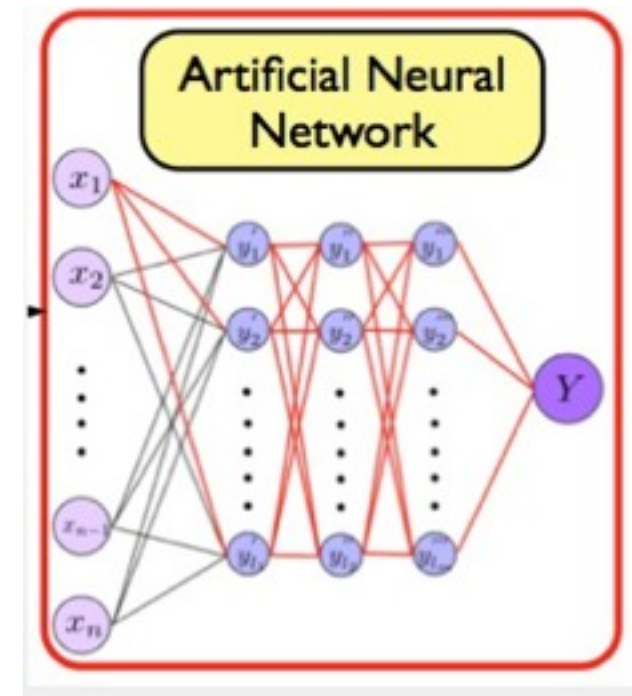
# Development of New Noise Characterization Tools



- **Realtime non-Gaussian noise modeling**
  - **In reality, even stationary noise is different from Gaussian noise.**
- **Globally detector network monitor**



# Multi-Channel Analysis



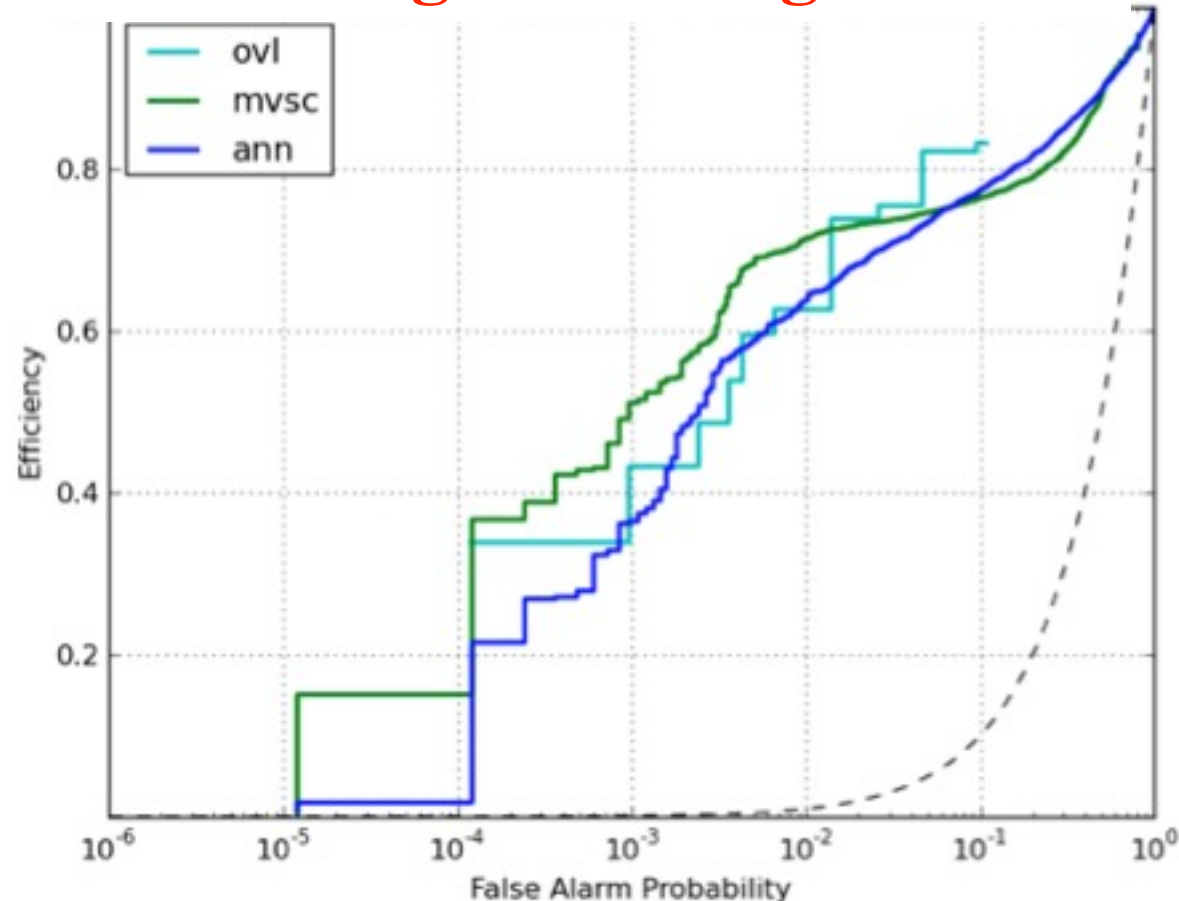
- Lead by Korean GW group
- Initial Goal:
  - Development of a method **for localize noise sources using auxiliary channels and PEMs** to support find/kill noise sources.
  - **KGWG has been developing ANN** based one for post-processing analysis in LVC.
  - We **focuses on a tool useful for commissioning.**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

# Integrating iDQ into HasKAL

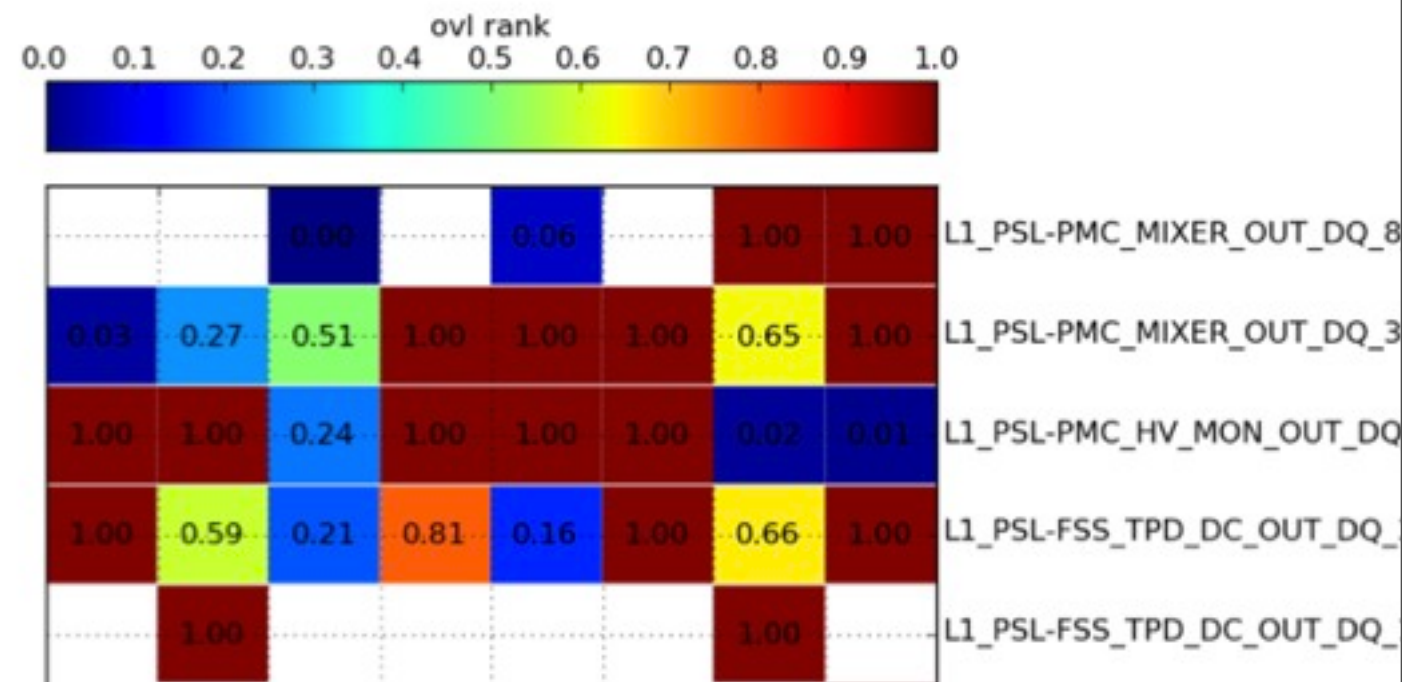
- a low-latency pipeline which makes event-by-event predictions about the glitchiness of GW data based on auxiliary channel informations and provides data quality information.
- Finding responsible channels of glitches

Will integrate iDQ into 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.

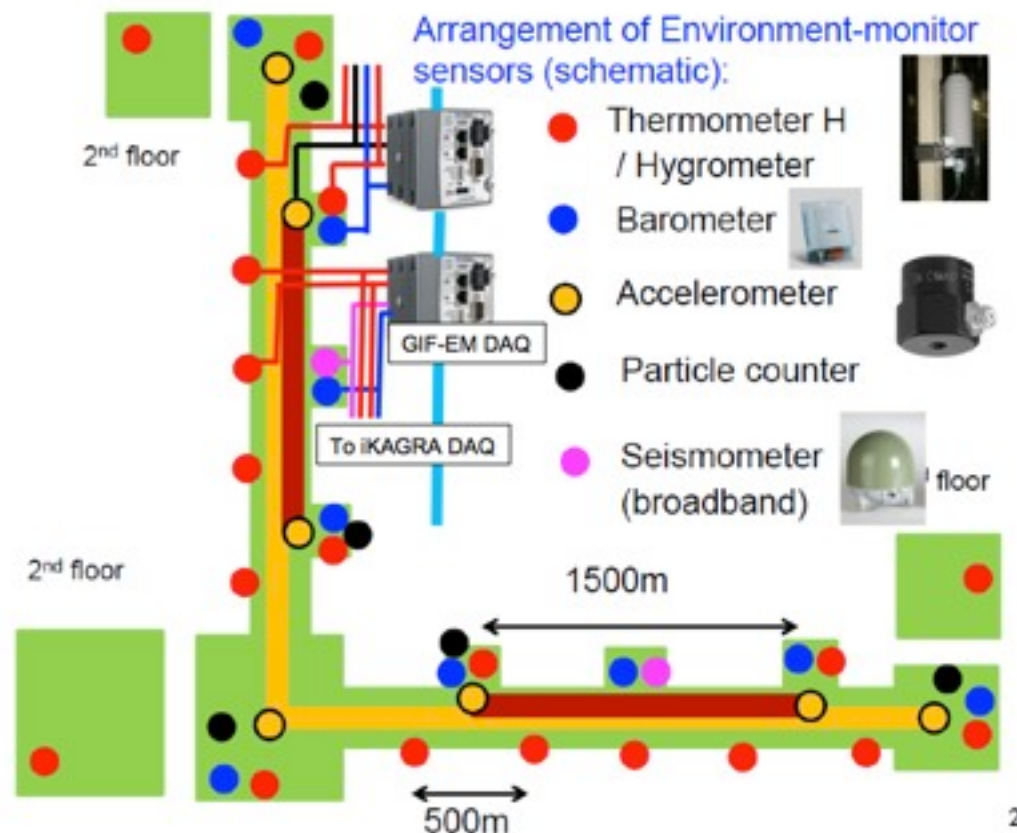
- A noise monitoring system for the cryogenic system is developed at TAMA 300.
- Our goal is to develop a system to reduce the false alarm rate to 1/month.



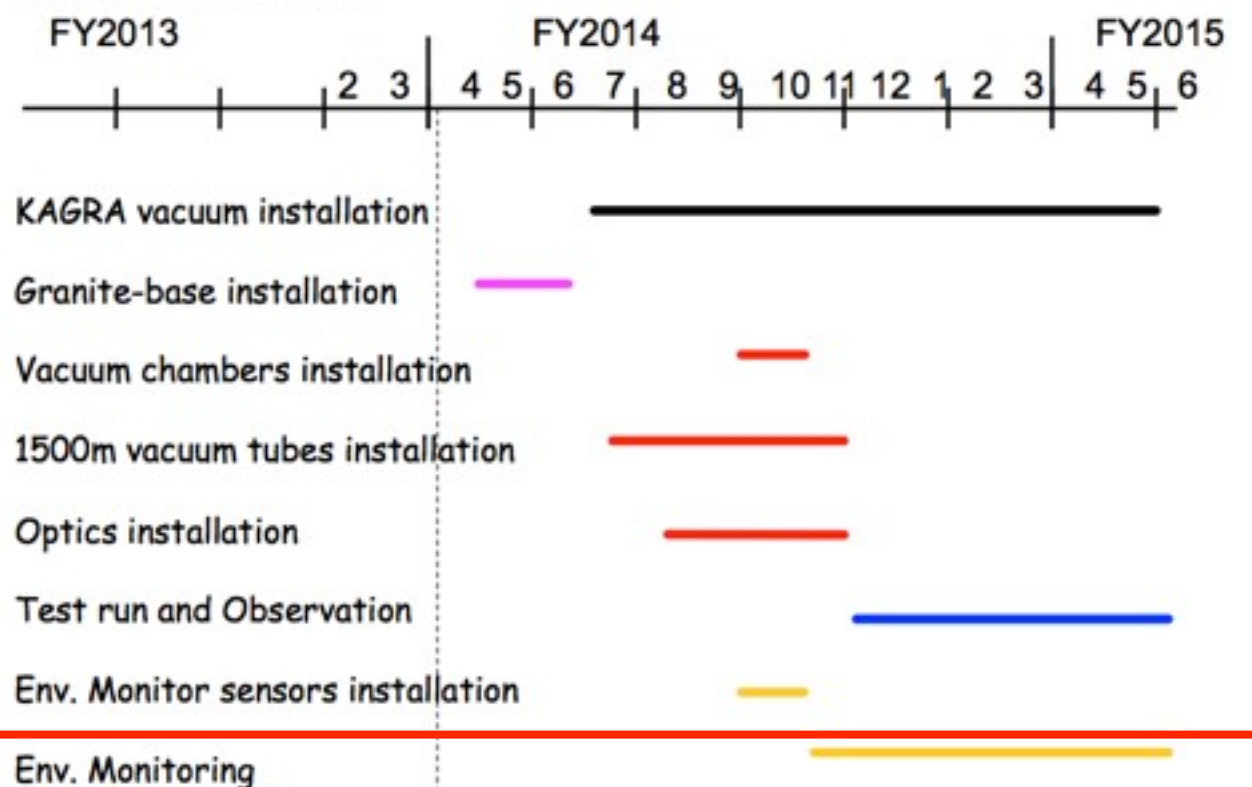


# Schedule

- ☑ 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/Developing system and tools.



Installation Schedule





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](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?

Rana

- **We developed/developing the detchar tools. Some of them are equivalent to LIGO tools and some of them are brand new.**
- **That does not satisfy us.**
- **To make them useful for speed-up commissioning, we need feedback / advice from subsystems. Now Akutsu-kun helps/gives us information about VIS->AOS up-conversion noise and we discuss how to find/characterize that noise and give him information to kill them. We would like to contact others and request helps.**



# TODO



- **Web-based detchar**
- **Data-base**

