Status of KAGRA detector characterization

Feb. 15, 2014

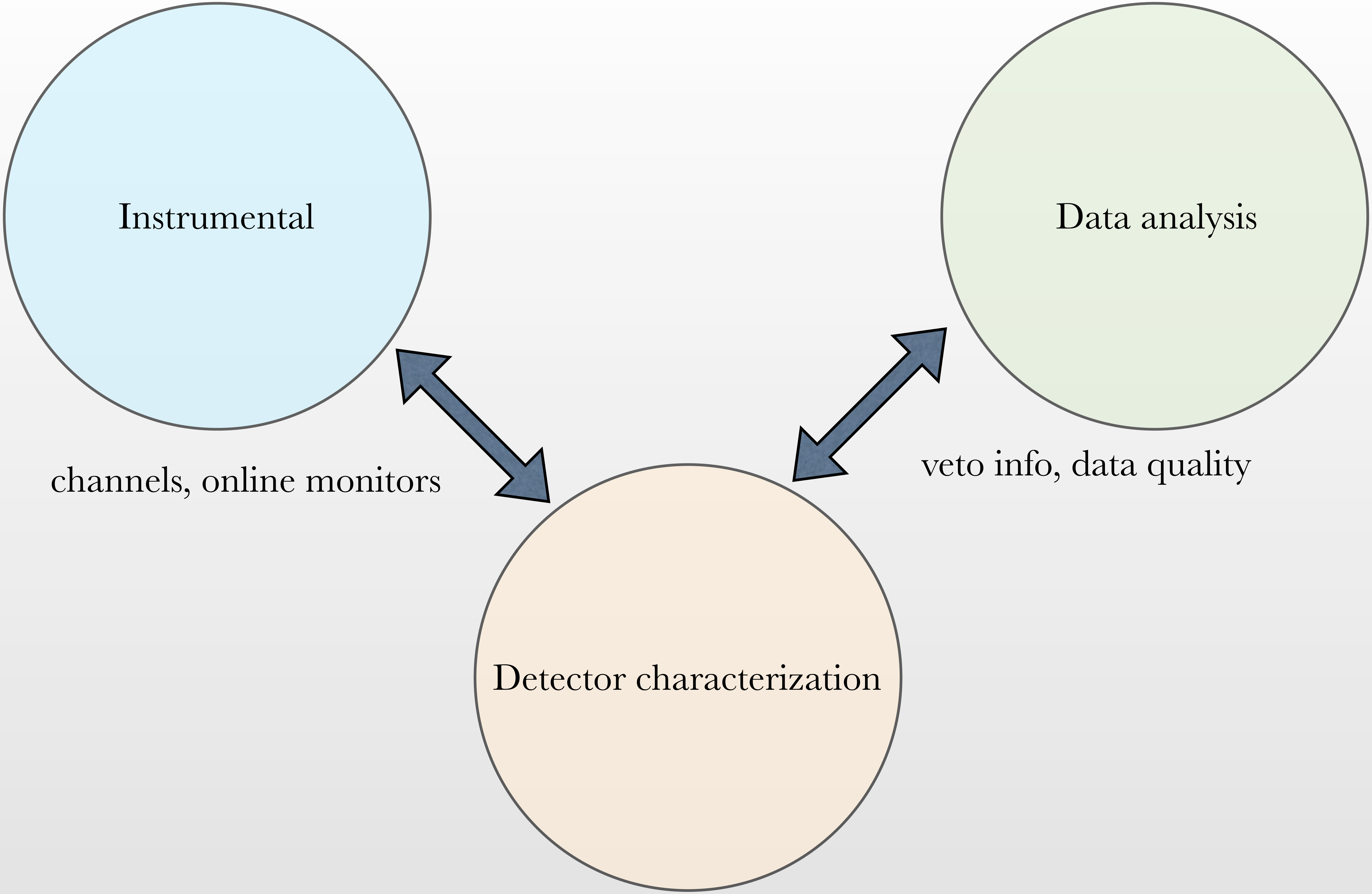
KAGRA f2f meeting

@ICRR

Detector Characterization Group

Takahiro Yamamoto

Interface of Detector Characterization



Role of detector characterization

- Commissioning phase
  - help to reach design sensitivity
- Observation phase
  - data quality flag
  - detector diagnosis
- Search phase
  - specialized veto for each analysis of GW sources

Commissioning phase

In order to make contribution to reach the design sensitivity

- We are preparing detchar tools/systems

    - To monitor lock information
    - To monitor detector sensitivity
    - To monitor transfer function at each instrument... etc.

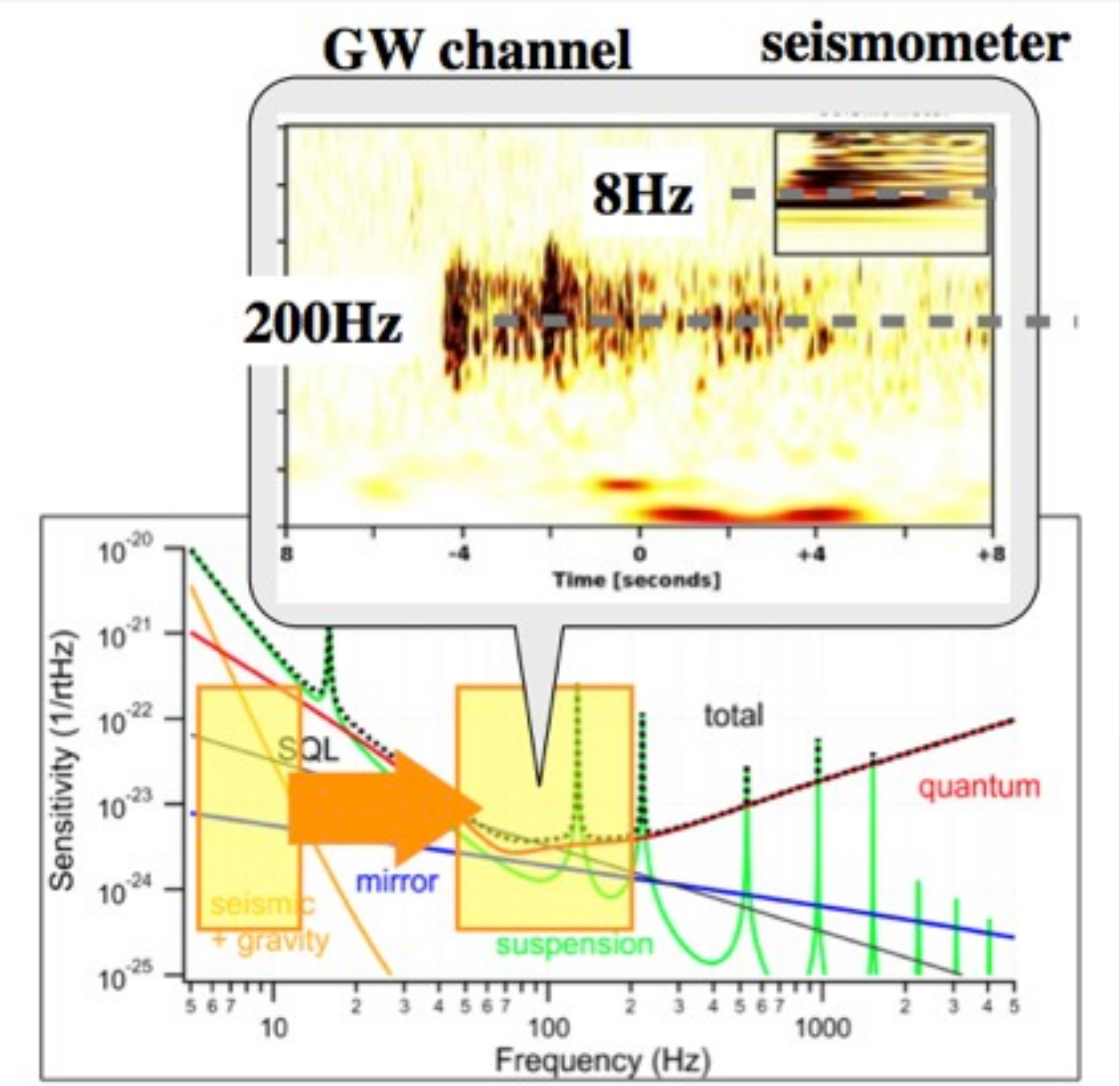
- It is also important to know **noise environment** at the KAGRA site

  We measured important noise sources: ***seismic activities*** and ***magnetic field*** at Oct. 21-25, 2013
  (Hayama, Ono, Yano, Uchiyama, Miyakawa, Yamamoto, Araya, Sekiguchi, Ohashi, Somiya)

❑ Seismic noise

○ There is up-conversion noise originated from seismic noise which affects observation bands.
To infer up-conversion noise it is important to know stationarity of seismic activities at the KAGRA site.

○ Though we already have seismic noise curve at the CLIO site we want to know that at the KAGRA site.



Sensitivity curve of KAGRA

Our questions are

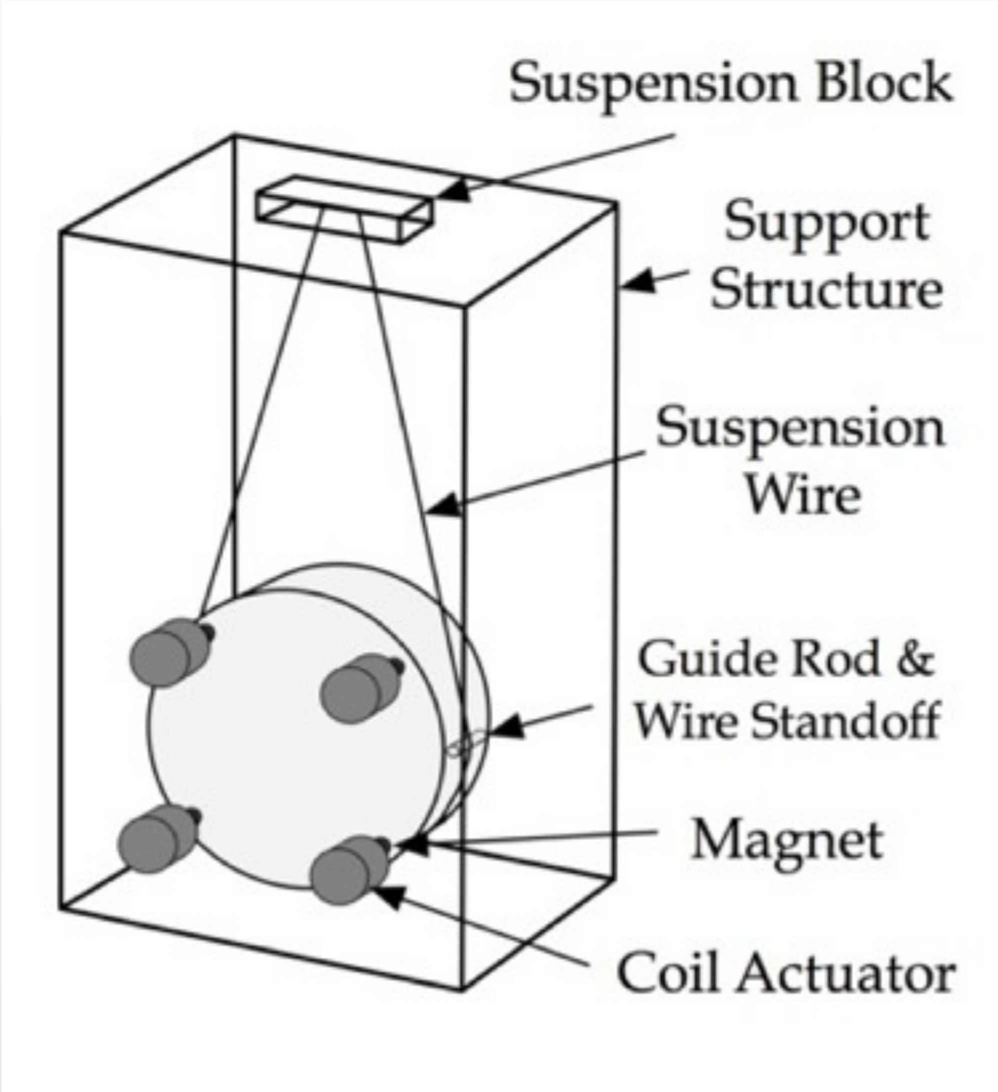
○ how different between at KAGRA site and at CLIO site

○ how is the stationarity of seismic activities at the site.

Magnetic field

○ Magnetic field affects sensitivity through magnet coil actuator

○ Non stationarity of the magnetic field causes increase of false GW events.



Our questions are

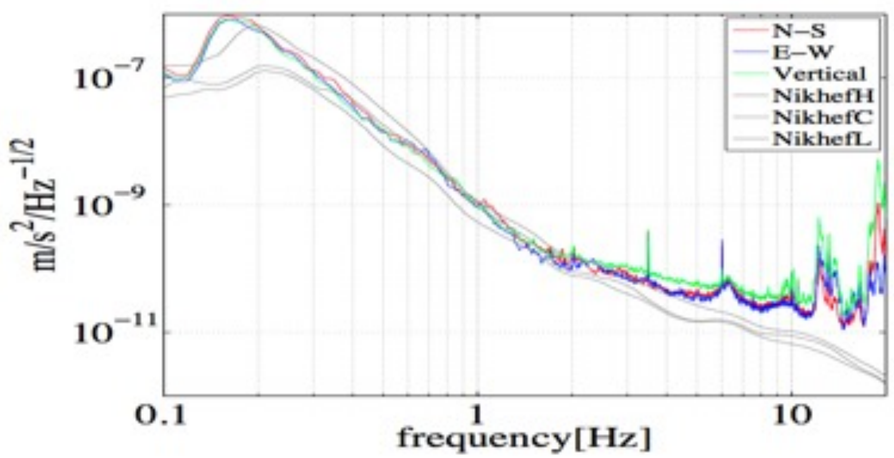
○ how is the magnetic field and its stationarity

○ what difference between in the mountain and out of the mountain

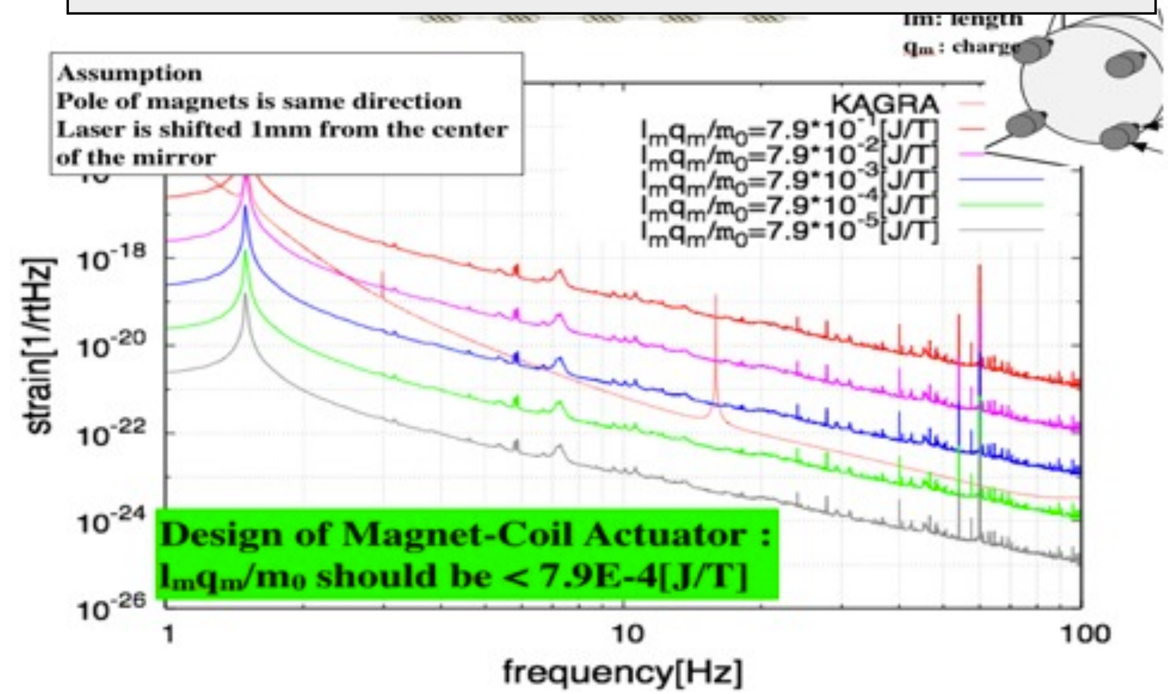
result of measurement noise

Measurement at the KAGRA site

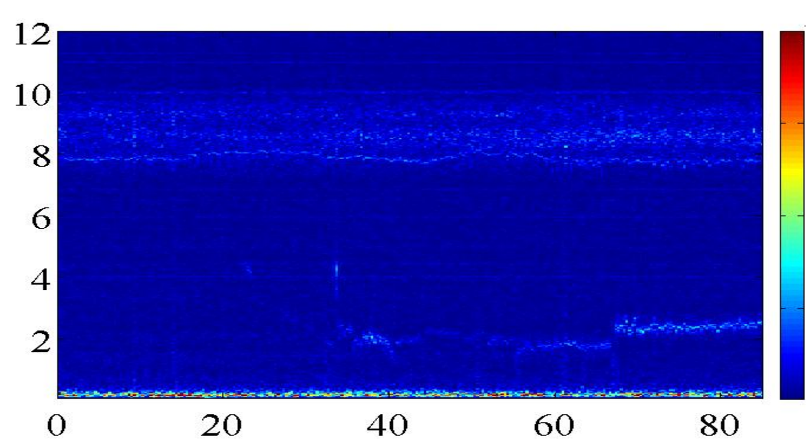
Seismic noise : < 2Hz consistent with CLIO
high frequency under investigation



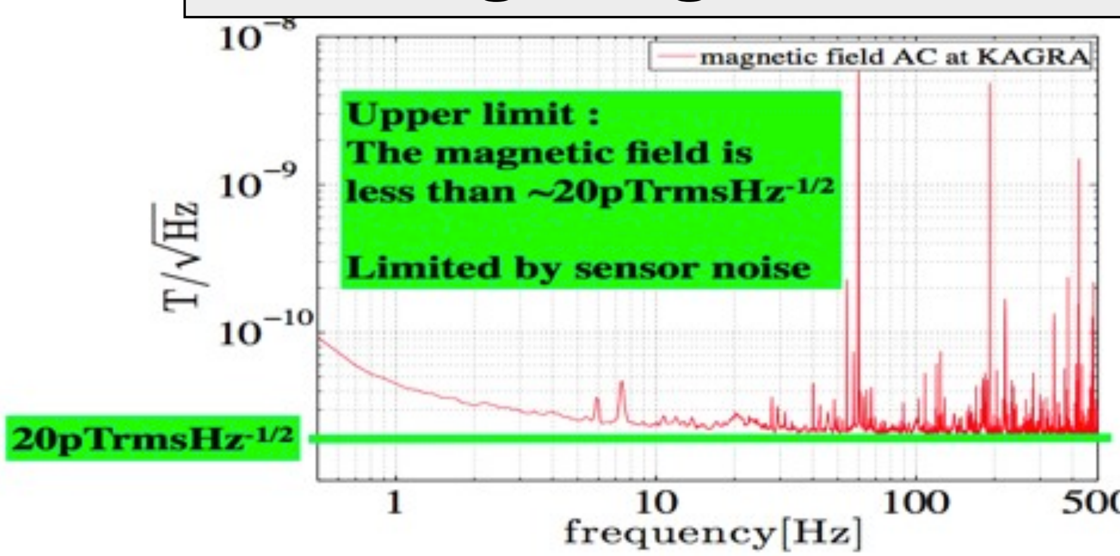
magnetic field :Requirement of Coil-magnet actuator



Stationarity:not bad, but longer data needed



No strange magnetic sources



by K. Hayama

Observation phase

- We define data quality flags by noise characterization
  - we use the data quality flags for deciding weather data is on science mode or not and so on.
  - categorization of the data quality flags are followings

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.

arXiv: 1203.5613

- Evaluation of the data quality in real time
  - important for multi-messenger observation such as sending alerts with low latency

- detector diagnostics to know its condition
  - To grasp lock information on real time
  - monitoring transition of detector sensitivity
  - monitoring transfer function at each instrument... etc.

DetChar Project

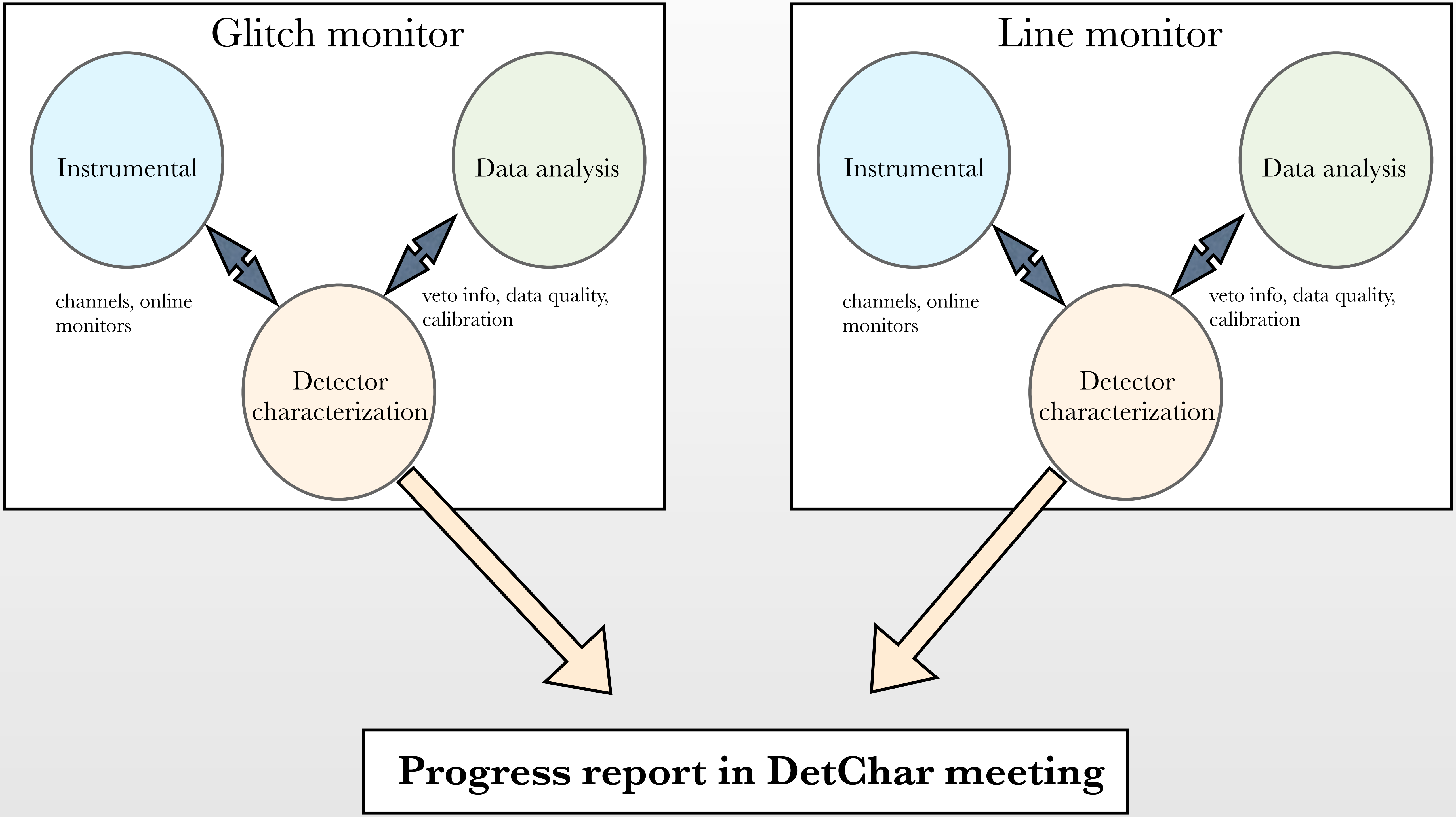
Primary Projects

- Detchar GUI system
- Glitch Monitor
- Line Monitor
- Gaussianity Monitor
- Noise Budget
- Health Monitor
- Data base
- Quality flag

Special Projects

- Globally correlated noise
- Violin mode
- Multi-Channel analysis
- Detchar shift
- Newtonian Noise
- Magnetic field and seismic noise at KAGRA site

Structure of DetChar Projects



Gaussianity monitor

P : Gaussianity Monitor

- Noise floor tracking
- Power spectrum
- Rayleigh distribution tracking
- Realtime noise modeling
- Monitor display

o Useful to know detector conditions.
o Useful to improve performance of GW search pipelines.

by K. Hayama

Line monitor

P : Line monitor

- Line detection
- Statistics (frequency,..)
- Characterization (duration, central frequency, power)
- Coherency check between channels
- Event display

o Useful to find weird oscillation of instruments in subsystems.
o Veto analysis

by K. Hayama

Glitch monitors

P : Glitch monitors

- Glitch detection
- Statistics (frequency,..)
- Characterization
- Coherency check between channels
- Event display

by K. Hayama

Data Quality flag

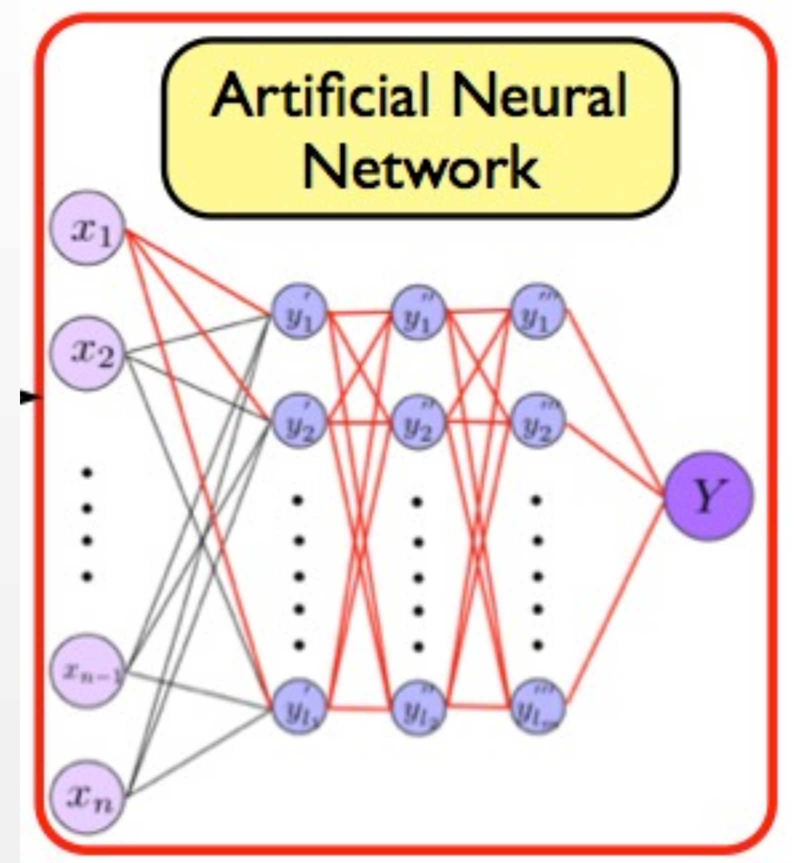
P : Data quality study

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.**

Multi-Channel analysis



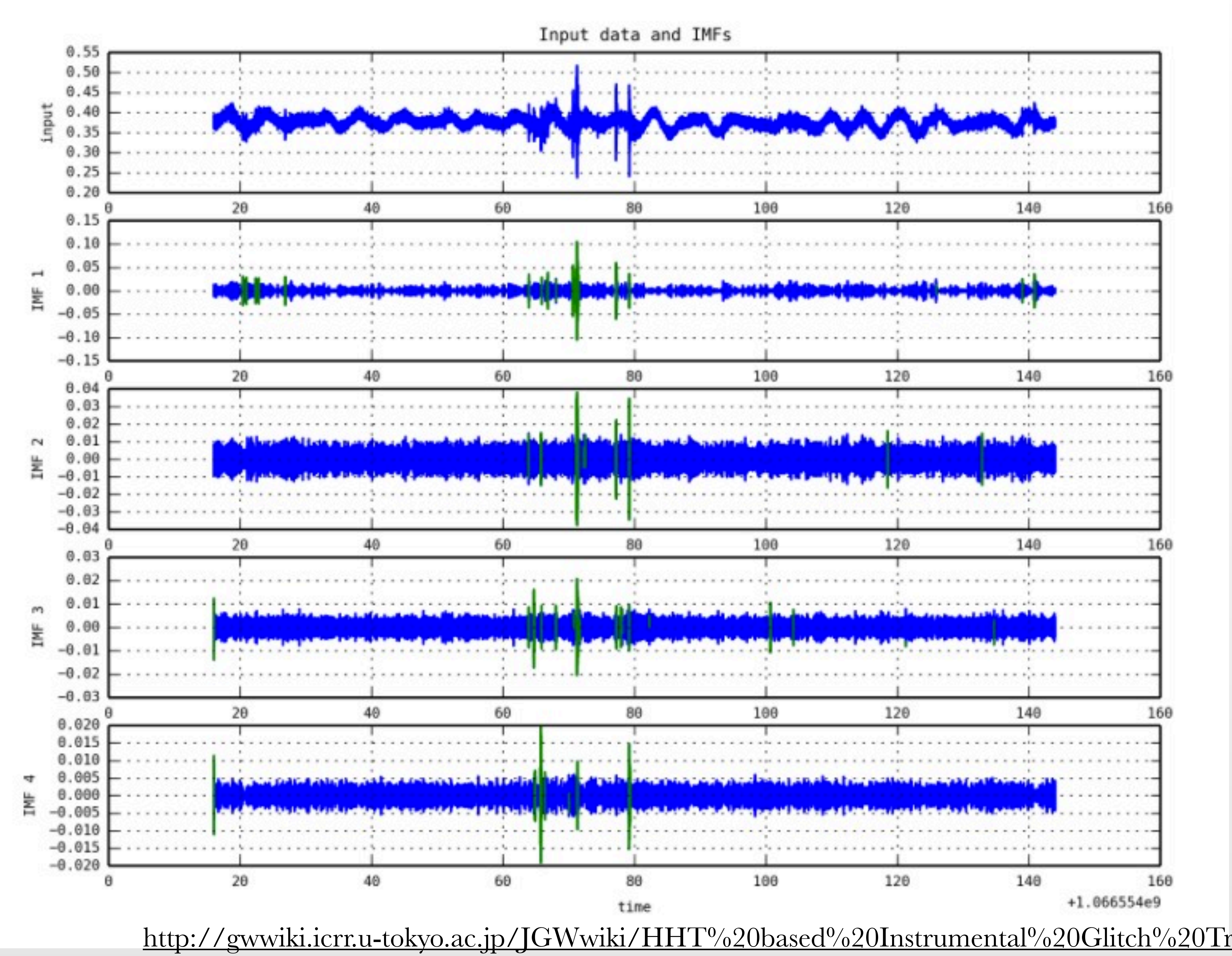
Y. Kim
4th KJ workshop 2013

KGWG leads this collaboration

Initial Goal:
Development of a method for localizing noise sources using auxiliary channels and PEMs.
Support to kill noise sources.

- So far several groups in LSC(including KGWG) have made their efforts on a post-processing analysis (mainly veto) to distinguish whether triggered events are glitches or not.
- Our project focuses on a tool useful for commissioning.

Another project KGWG is leading



http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/HHT%20based%20Instrumental%20Glitch%20Trigger%20Generation

They are analyzing magnetic noise data at the KAGRA site.

Multi-Channel analysis

S : Un-supervised glitch clustering

Shuhei Mano
The Institute of Statistical Mathematics, Japan

- From the experience of TAMA300, LIGO, Virgo, there are glitch families, but the number is unknown.
- Identification of glitch families is important to exclude their origins.
- We propose a Bayesian clustering method
  - Dirichlet process Mixture can find how many clusters exist, how they are distributed.
  - Test pipeline are ready to go, now discussing how we construct the input vector.

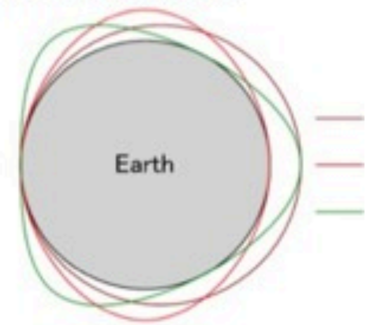
http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/KAGRA/Subgroups/DET/Meet/Agenda20131126?action=AttachFile&do=view&target=gw1311.pdf

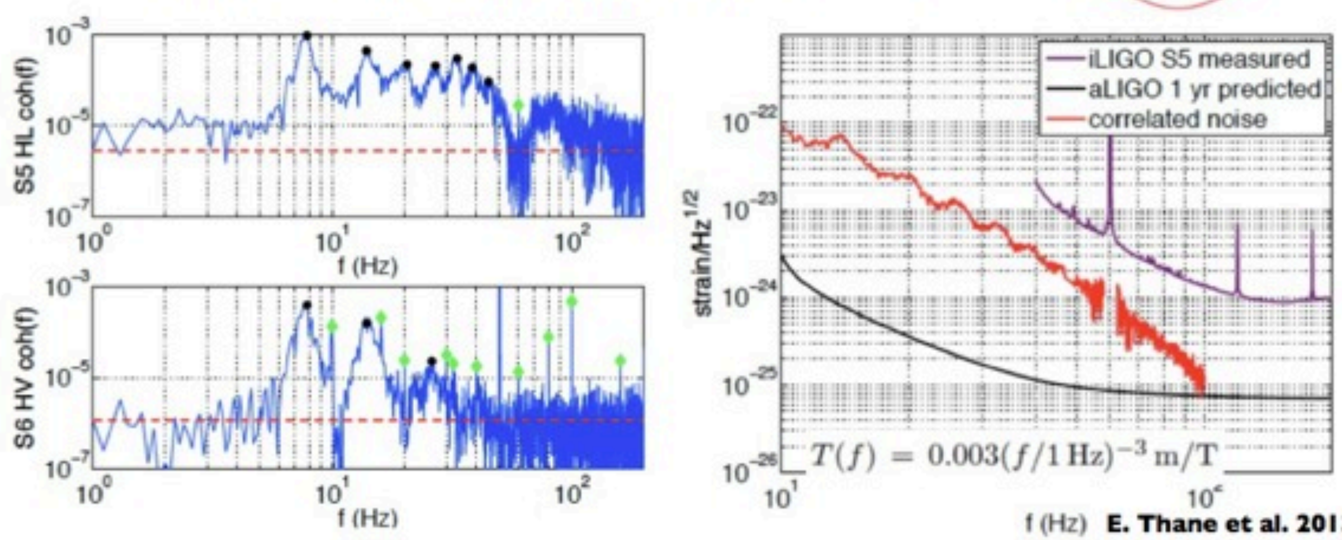
Globally correlated noise

S : Globally Correlated Magnetic Noise

Atsushi Nishizawa
Kyoto Univ.

- 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

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.

Monitor tools

○ Some monitors are implemented
Glitch Monitor: KleineWelle current running

○ KleineWelle, developed in LSC, is widely used in LIGO and Virgo so it is useful to compare detector condition with LIGO and Virgo using the same tool.

○ KleineWelle is not so sensitive monitor but because of the very light computation cost it is useful many channel at the same time.

○ This monitor not only read real time data via NDS but also past data from stored frame data.

DetChar GUI system

We will develop detchar tools using KAGALI, LAL and so on

For now we are developing haskell based wrapper for these libraries called HasKAL

Haskell is functional language and to construct libraries is easier than another language

HasKAL is developed on Linux machine at Hokubu-kaikan
in order for the development at the realistic computational environment
that means integration of KAGRA digital system, DAQ system, NDS server etc.

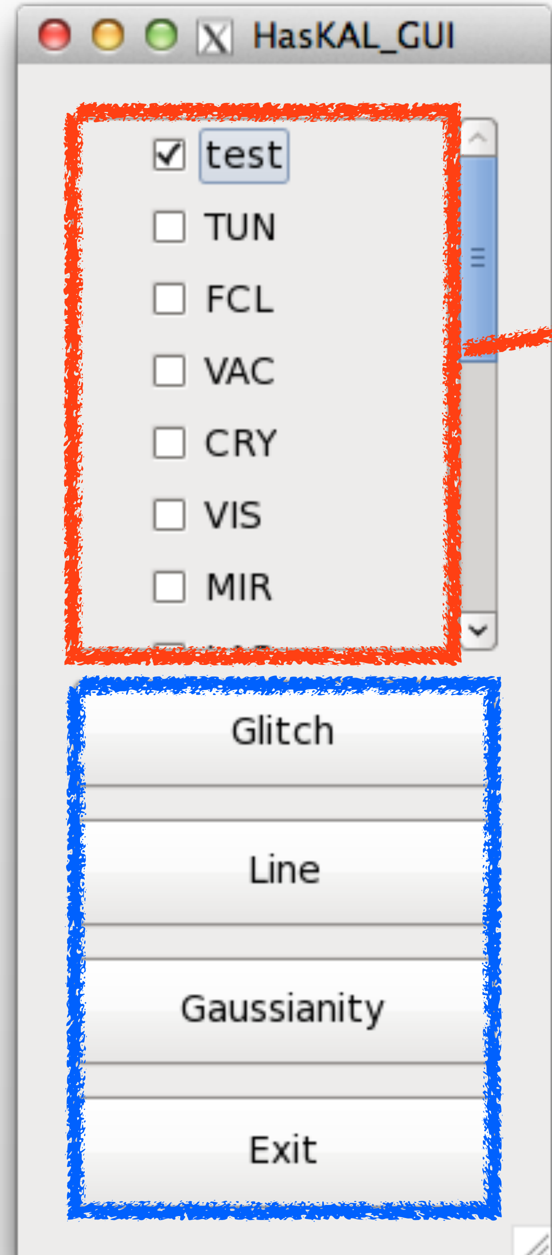
- HasKAL／
  - GUI_Utils／ — main GUI frame
  - PlotUtils／ — plot tools like Chart
  - FrameUtils／ — IO frame file
  - MonitorUtils／ — monitor tools like KleineWelle
  - ExternalUtils／ — wrapper for external library

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

We would like to contribute to gravitatinal wave comunity
by providing haskell wrapper to the libraries.

GUI Demonstration

select sub group (left)
display channel list (right)

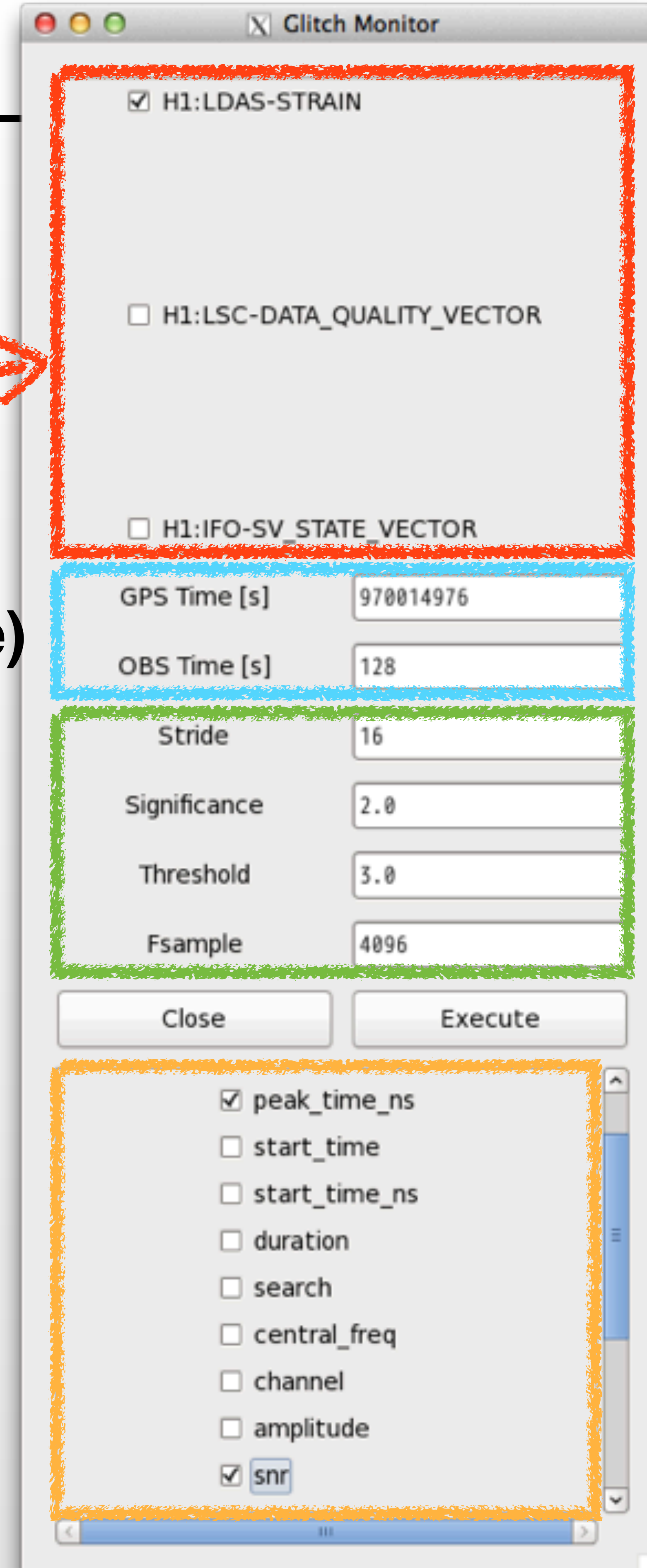


select Monitor tool

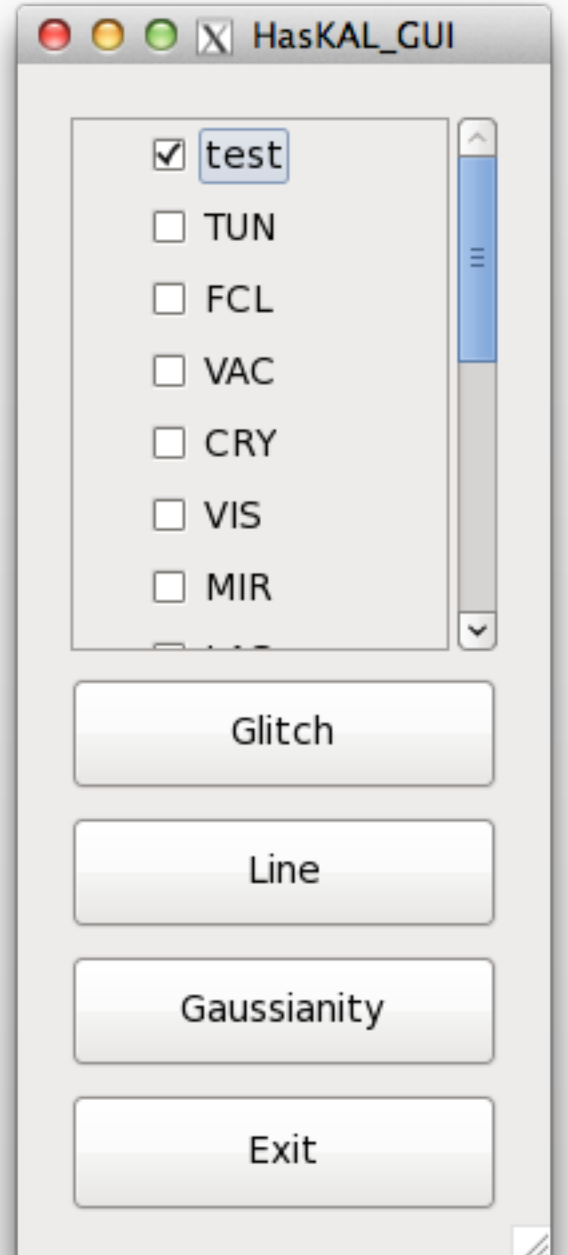
select data file(GPS time)

KleineWelle's options

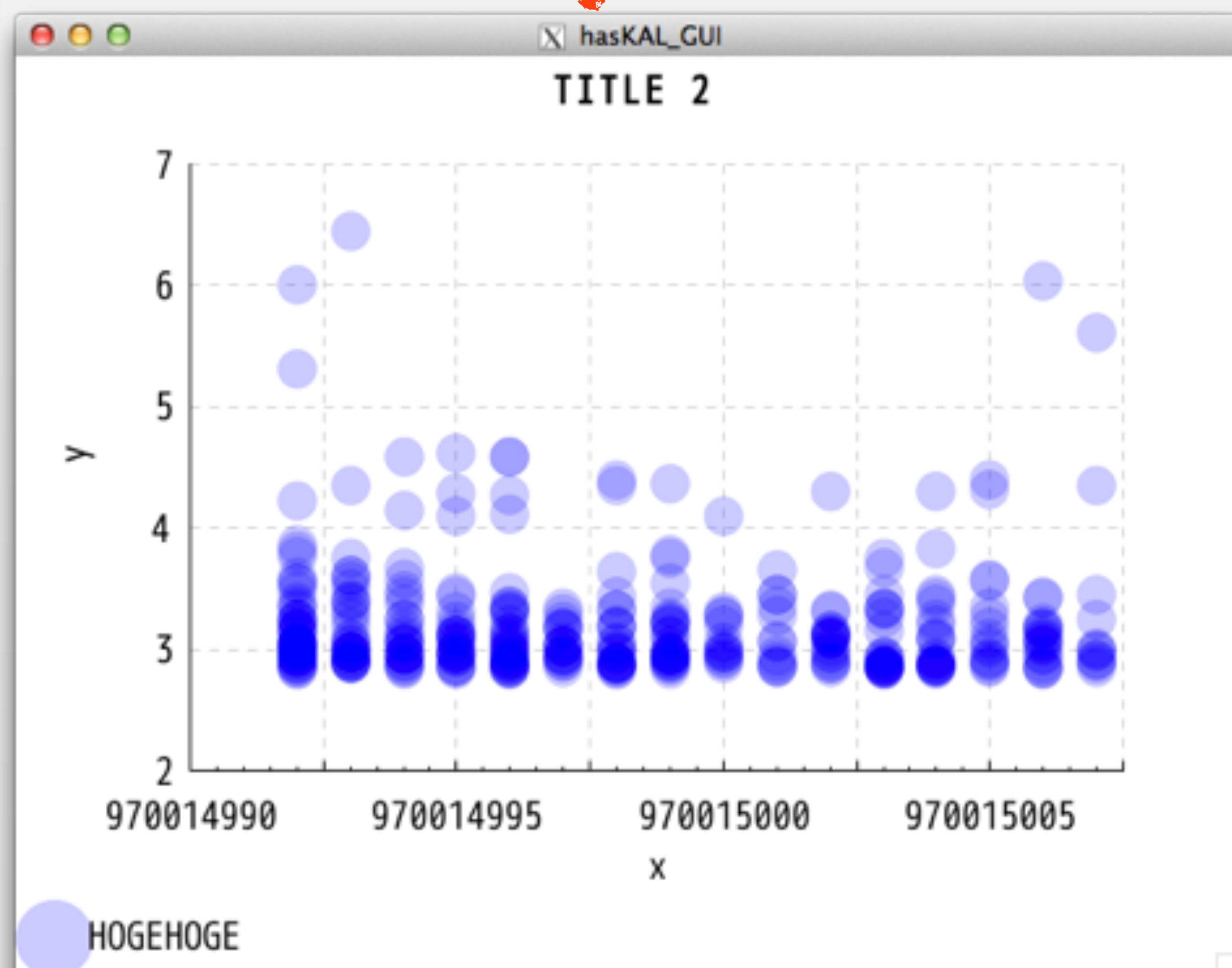
select axis of plot (2D or 3D)

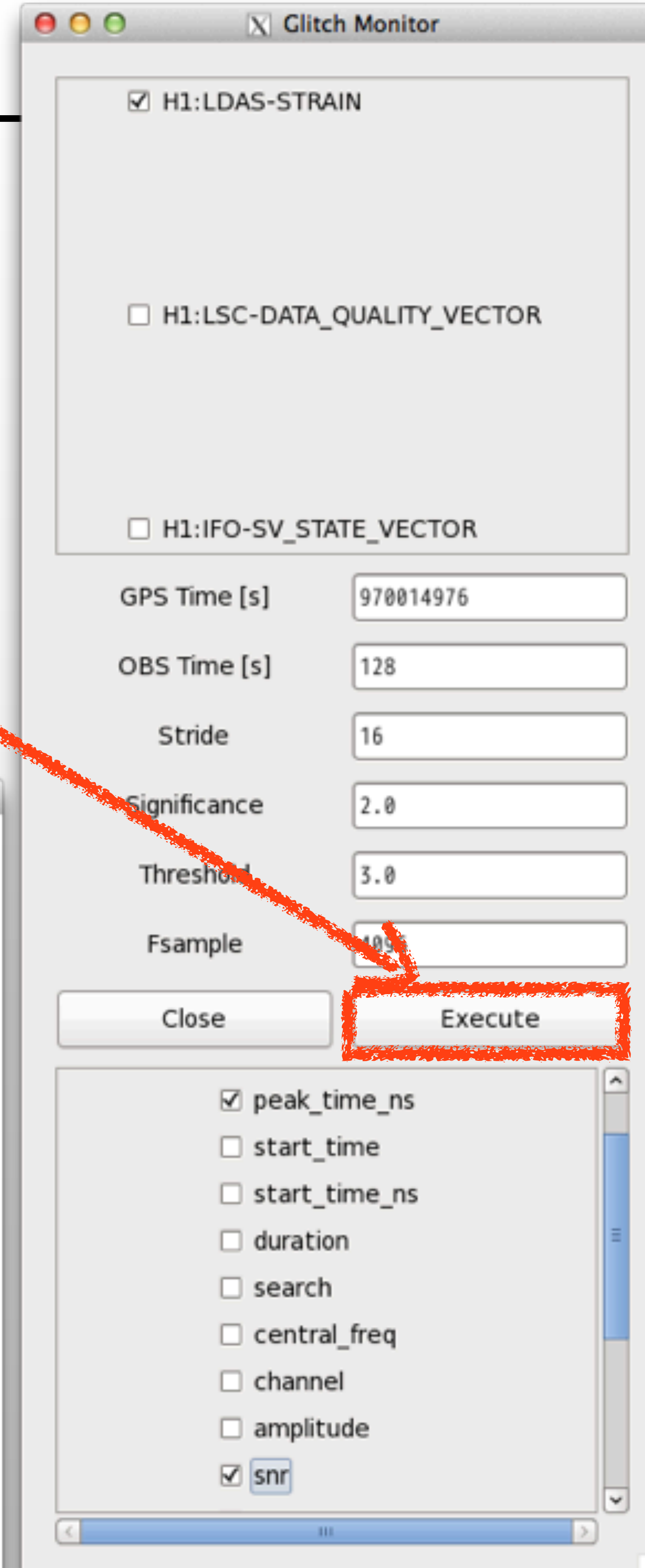


GUI Demonstration



After pushing Execute running KleineWelle and showing Plot





Collaboration with Virgo DQ group

With help of Prof. Flaminio and Prof. Vinet ...
we could have close collaboration with Virgo DQ group

- Access to Virgo PEM data
- We start having collaboration meeting on 17 Jan.
- We plan to have regular meeting
- Exchange information
- Collaborative work of the development