# KAGRA detector characterization

Kazuhiro Hayama

# Summary

## For helping quick commissioning

- Subsystem detector characterization
  - ADC noise, stationarity, lines, glitchness, noise budget
- Multi-subsystem detector characterization
  - Eg. one of up-conversion noise mechanism is
    seismic glitch -> optical bench excited -> scattered noise
    VIS -------- AOS correlated noise
  - Need Multivariate analysis (correlation analysis like hveto, multi-channel analysis using ANN (KoreaGWG), unsupervised machine learning)
- Realtime DetChar machine
  - Detchar GUI -- providing user-friendly tools to analyze PEM monitors, channels
  - Automatic detchar summary page generation -- for daily looking of subsystem's condition

## For stable observation

Real-time data quality flag
Data quality categorization consistent with LIGO, Virgo, but some unique system s.t. cryogenic

## Software development

Tools developed in LVC will be used -- good for comparison of DQ with LIGO, Virgo
Besides that, new tools are being developed using LAL, maybe KAKALI,

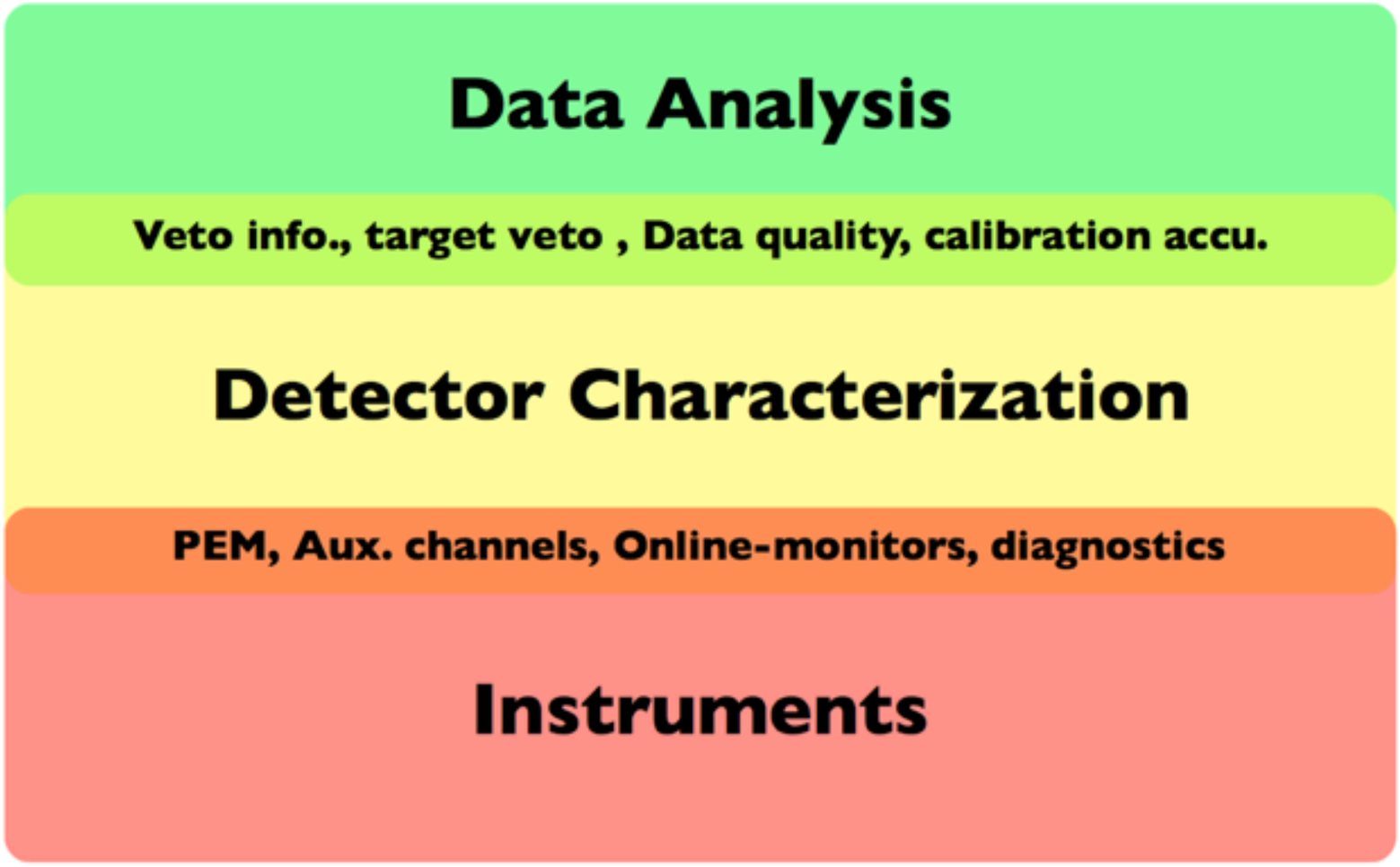
# Schedule

- **2014 April : Test of detchar GUI on VIS digital system at NAOJ. We hope 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.**

# Scope of the detector characterization




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

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

# Subsystem detector characterization

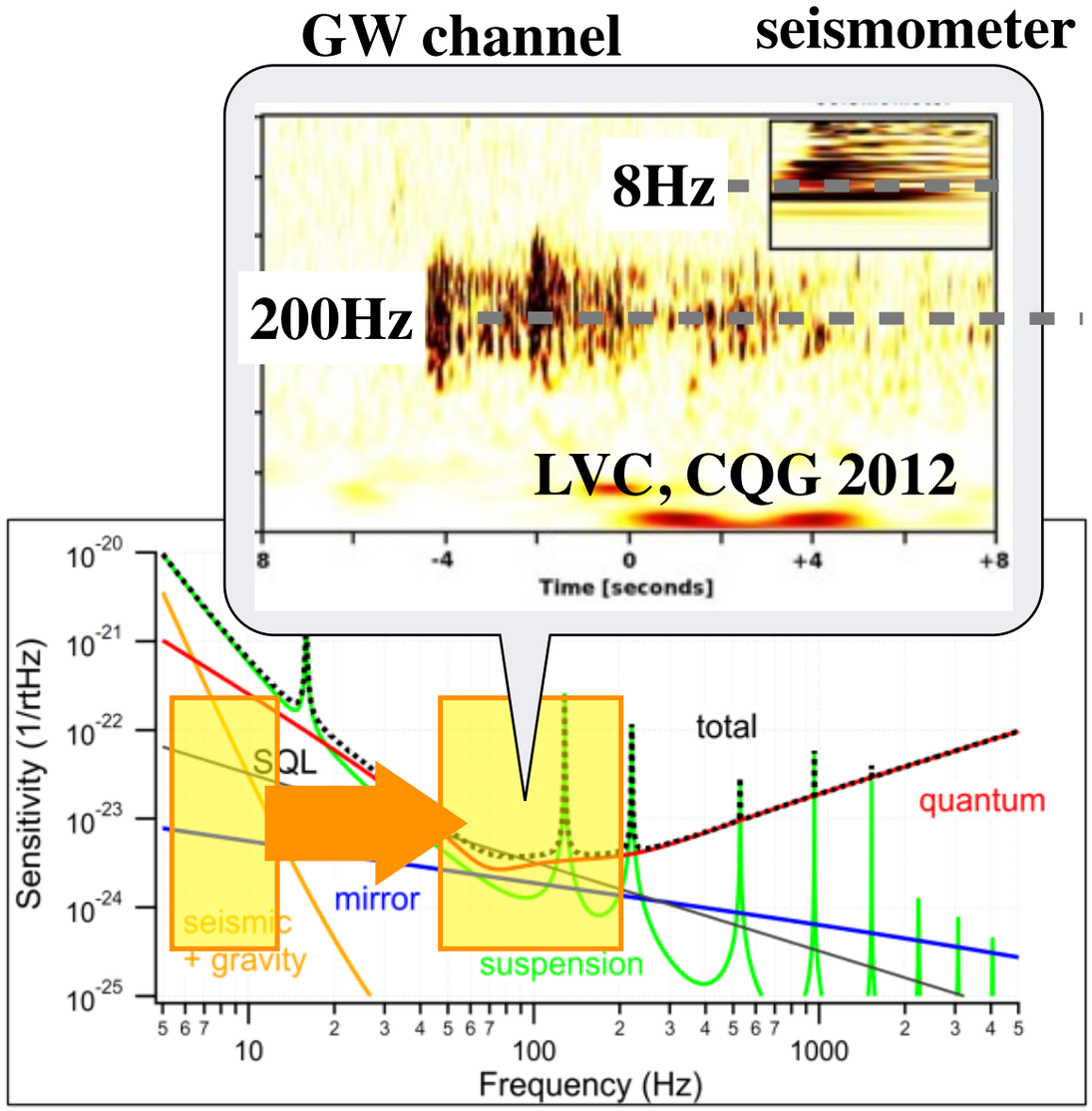
## Speed-up commissioning

- Subsystem Diagnostics
  - ADC noise is within range?
  - Whitening requirement?
  - Channel correlated noise?
  - Find good frequency region for calibration
  - Components consisting the subsystem is healthy?
  - 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

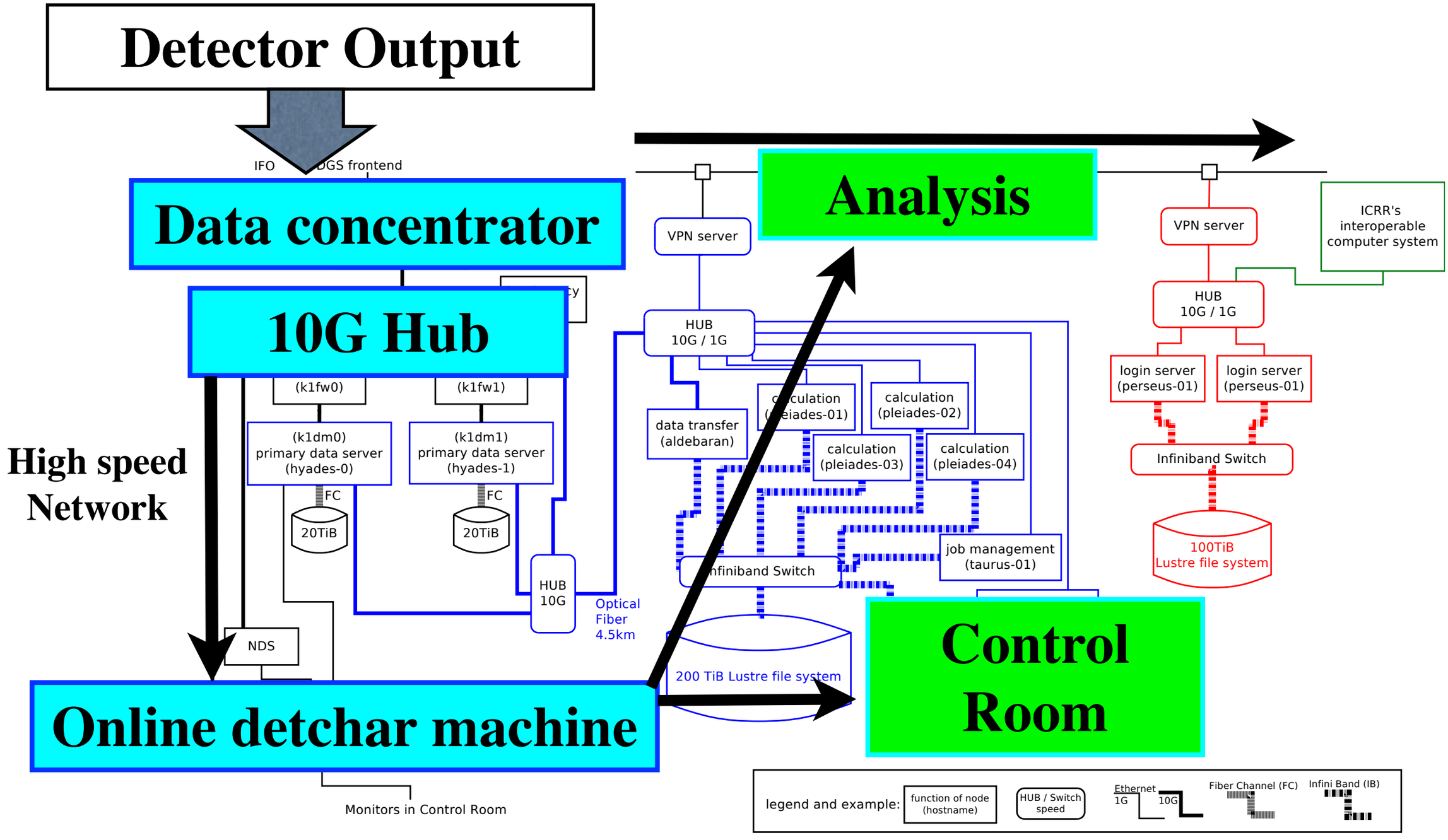
## Categorization of data quality

| 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<br>• Glitch classification<br>• Coincidence analysis between the GW channel and auxiliary sensor channels.<br>• ... | • Line tracking<br>• Line detection<br>• Removal of high frequency spikes<br>• ... | • Noise floor monitor<br>• Non-stationary<br>• ... |

# Data flow




Realtime channel monitor

Kanda

# On going DetChar projects

## Primary Projects

- To maintain Diagnostics Test Tool(Hayama, Miyakawa)
- Detchar GUI (Yamamoto)
- Detchar summary page (Hayama)
- Glitch Monitor (Hayama)
- Line Monitor (Itoh)
- Gaussianity Monitor (Hayama)
- Noise Budget(Miyakawa Hayama)
- Health Monitor
- Data base

## Special Projects

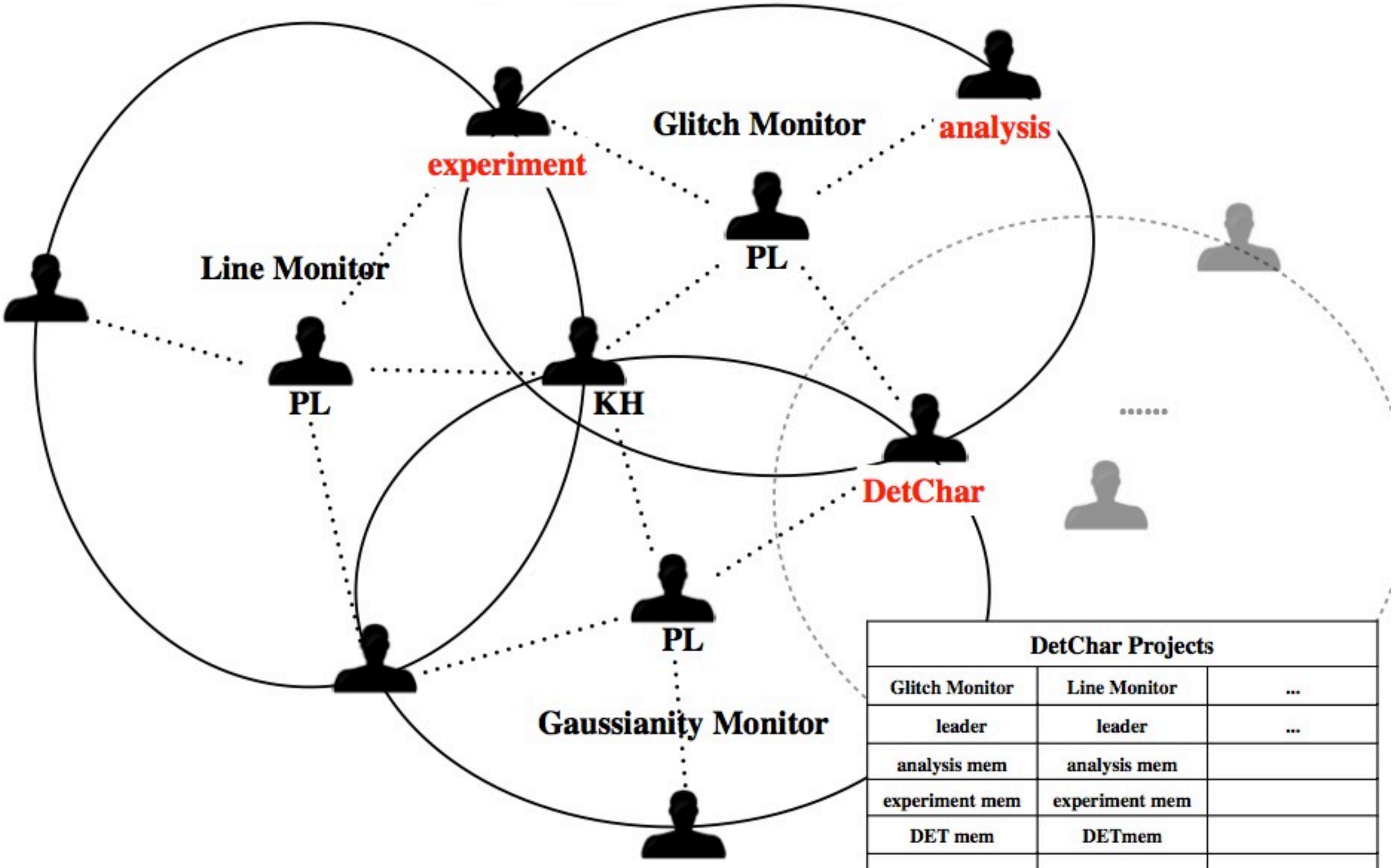
- Globally correlated noise (Nishizawa, Hayama, ...)
- ☑ Violin mode(Hayama,Sekiguchi,..)
- Multi-Channel Analysis (Hayama with Korea detchar, Mano)
- Detchar shift plan(Hayama)
- Newtonian Noise

● in progress

● in slowly progress

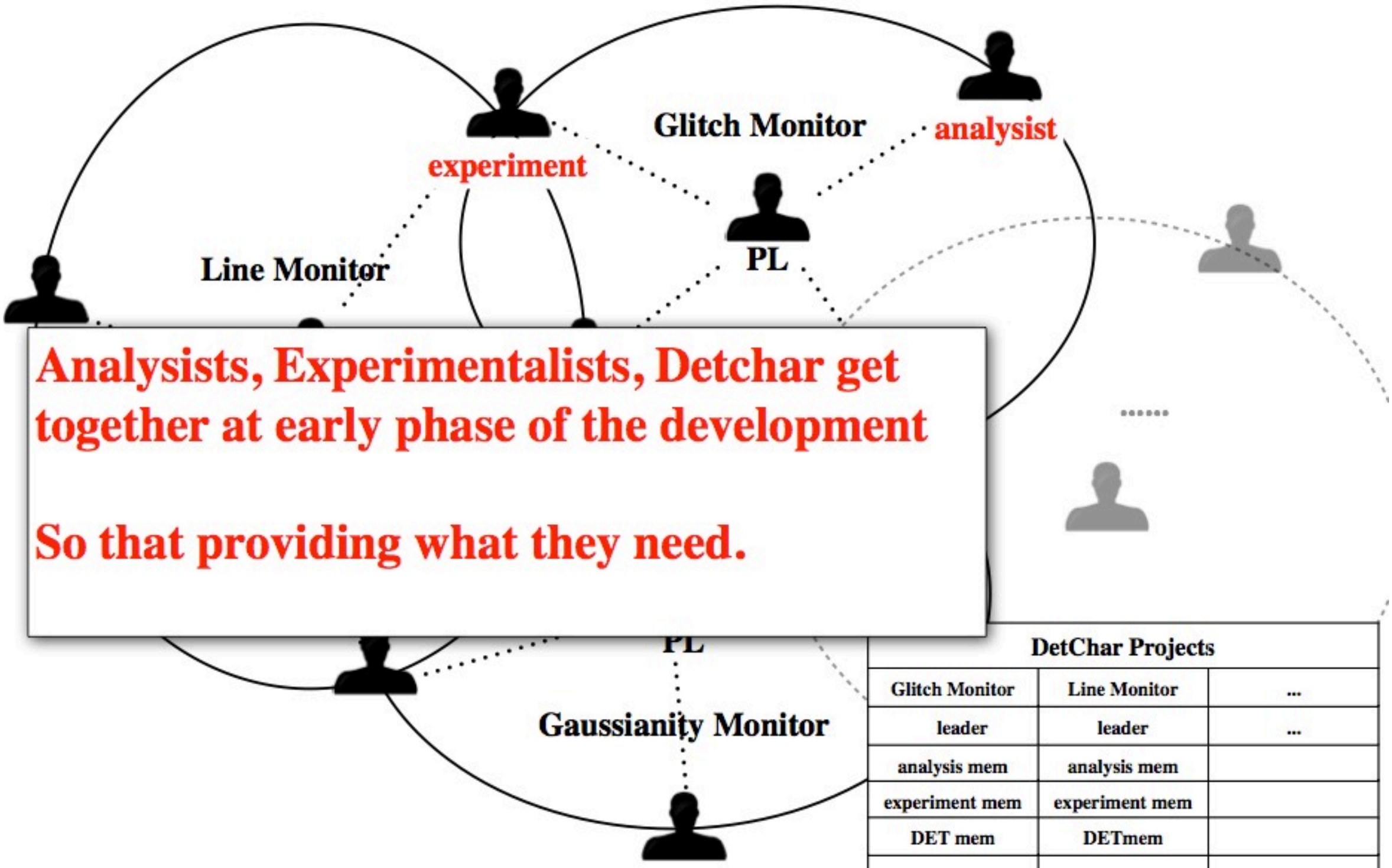
http://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=1724

# Structure of the projects




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

# Structure of the projects




**Analysists, Experimentalists, Detchar get together at early phase of the development**

**So that providing what they need.**

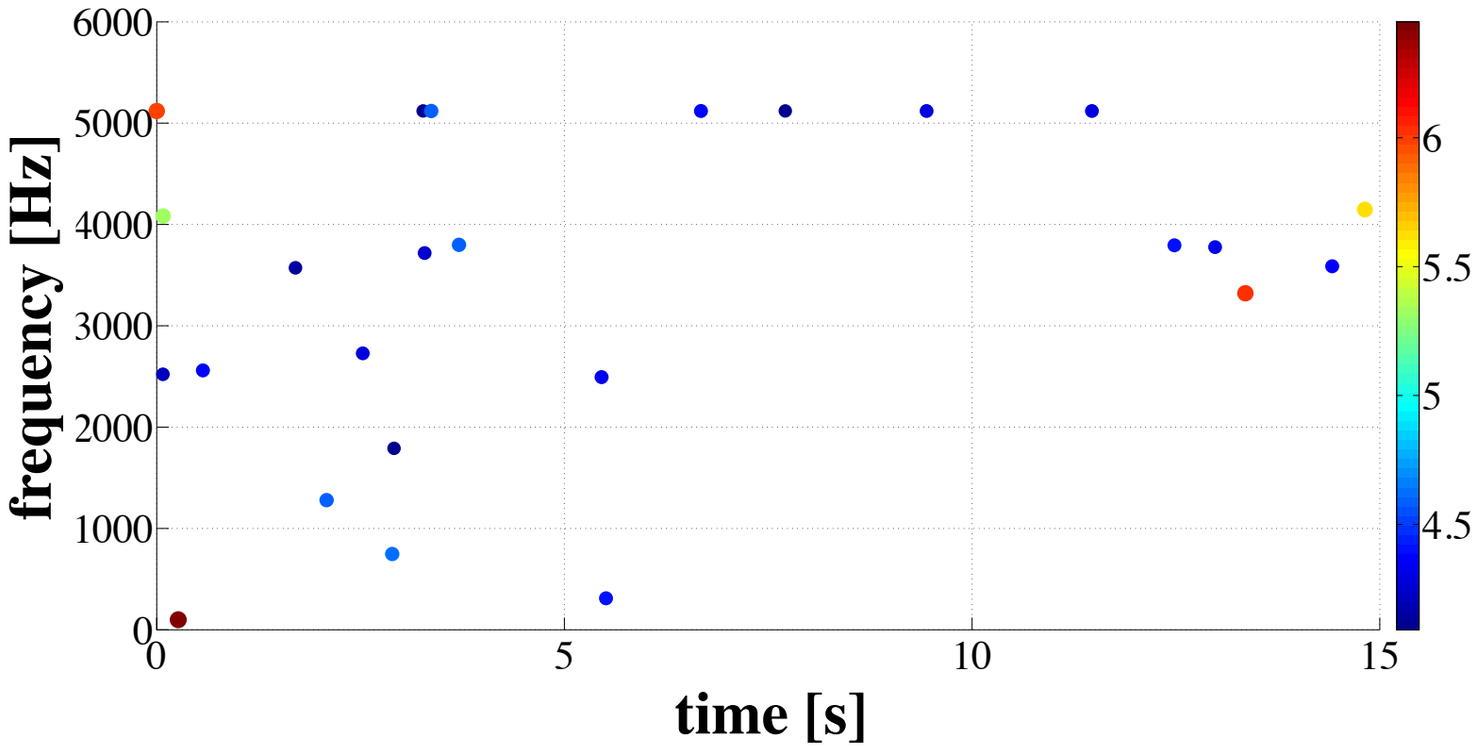
| DetChar Projects | | |
|---|---|---|
| Glitch Monitor | Line Monitor | ... |
| leader | leader | ... |
| analysis mem | analysis mem | |
| experiment mem | experiment mem | |
| DET mem | DETmem | |
| | | |

# P : Glitch monitors

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

# P : Glitch monitors

- **Some monitors are running:**
  **KleineWelle, ...**
- **KW is used in LIGO, Virgo: useful to compare detector conditions with the same algorithm.**




**XML formatted data**

```
<?xml version="1.0"?>
<!DOCTYPE LIGO_LW SYSTEM "http://gateway/doc/ligolwAPI/html/ligolw_dtd.txt">
<LIGO_LW Name="ligo:ldas:file">
  <Table Name="sngl_burstgroup:sngl_burst:table">
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    <Column Name="sngl_burstgroup:sngl_burst:peak_time" Type="int_4s"/>
    <Column Name="sngl_burstgroup:sngl_burst:peak_time_ns" Type="int_4s"/>
    <Column Name="sngl_burstgroup:sngl_burst:start_time" Type="int_4s"/>
    <Column Name="sngl_burstgroup:sngl_burst:start_time_ns" Type="int_4s"/>
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    <Column Name="sngl_burstgroup:sngl_burst:channel" Type="lstring"/>
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    <Column Name="sngl_burstgroup:sngl_burst:chisq" Type="real_8"/>
    <Column Name="sngl_burstgroup:sngl_burst:chisq_dof" Type="real_8"/>
    <Column Name="sngl_burstgroup:sngl_burst:bandwidth" Type="real_4"/>
    <Column Name="sngl_burstgroup:sngl_burst:event_id" Type="ilwd:char"/>
    <Column Name="sngl_burstgroup:sngl_burst:process_id" Type="ilwd:char_u"/>
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      "",970014992,24047851,970014992,23925781,0.000244141,"kleineWelle",5120,
      "H1_LDAS-STRAIN_16_4096",1,3.32266,0,0,0,6144,"sngl_burst:event_id:0",
      "IBMRCBMwSAAAAQEAAA==",
      "",970014992,26245116,970014992,26123046,0.000244141,"kleineWelle",5120,
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      "IBMRCBMwSAAAAQEAAA==",
      "",970014992,27465820,970014992,27343750,0.000244141,"kleineWelle",5120,
      "H1_LDAS-STRAIN_16_4096",1,3.85443,0,0,0,6144,"sngl_burst:event_id:2",
      "IBMRCBMwSAAAAQEAAA==",
      "",970014992,65307616,970014992,65185546,0.000244141,"kleineWelle",5120,
      "H1_LDAS-STRAIN_16_4096",1,3.14791,0,0,0,6144,"sngl_burst:event_id:3",
```

# P : Line monitor

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

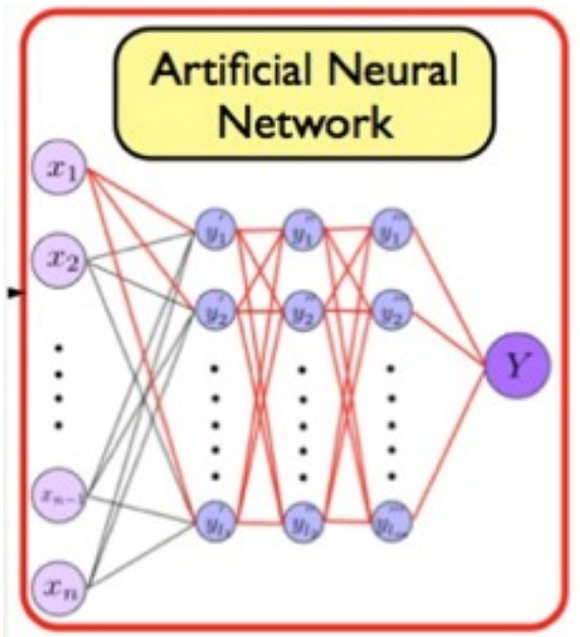
o Useful to find weird oscillation of instruments in subsystems.
o Veto analysis

# 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.

# S: 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.

# 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

# Collaboration with Virgo DQ

**We could have close collaboration with Virgo DQ**

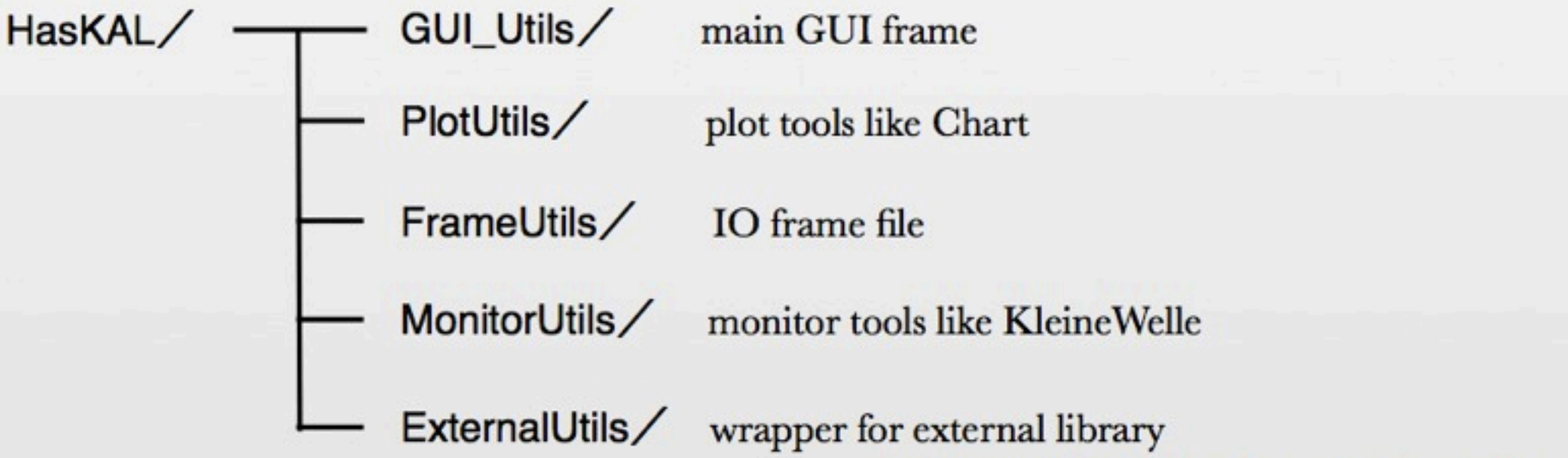
- **Access to Virgo PEM data**
- **We start having collaboration meeting on Jan 17**
- **We plan to have regular meeting.**
  - **exchange information.**
  - **collaborative work on the development.**

# 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

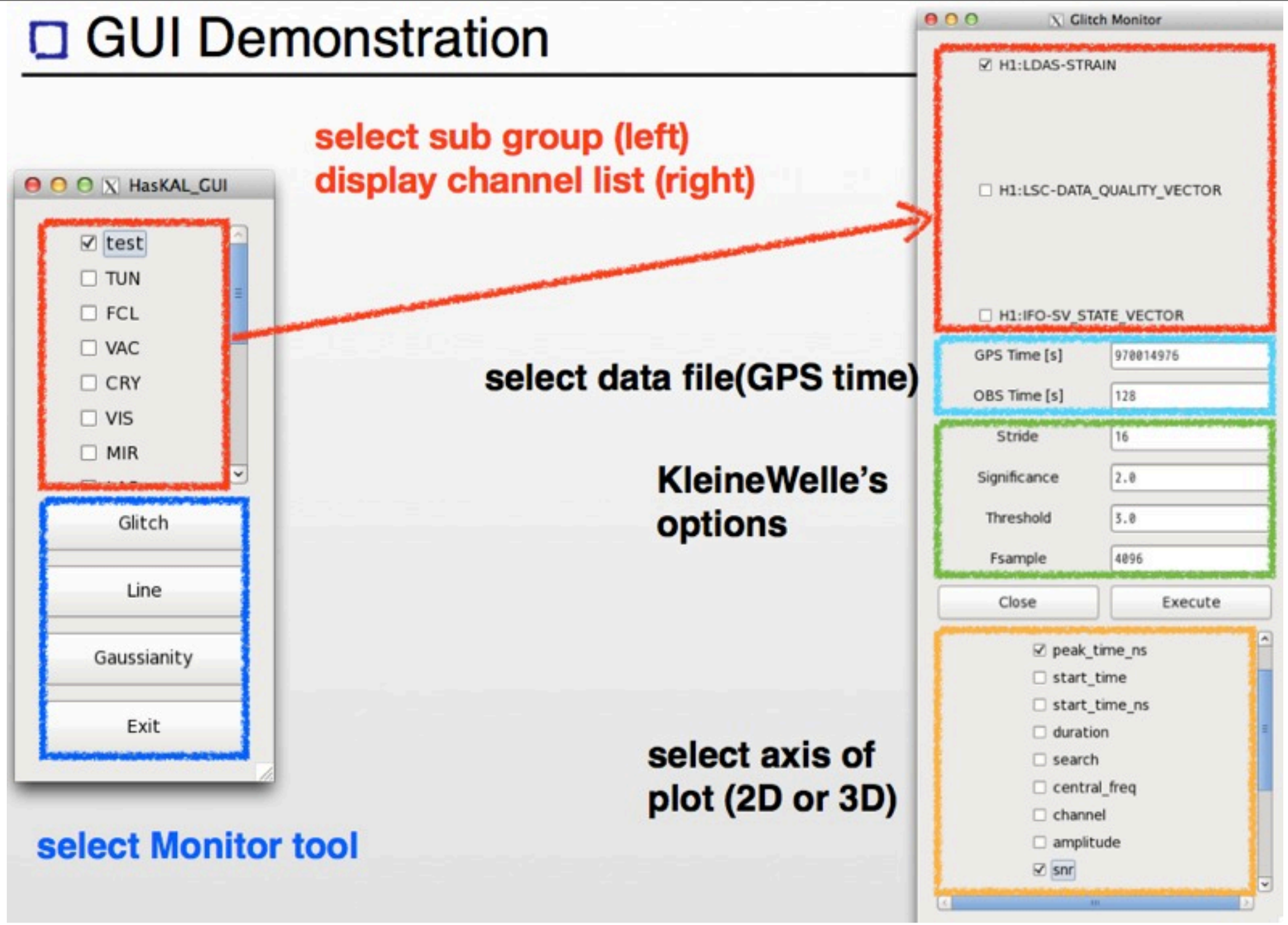
HasKAL is developed on Linux machine at Hokubu-kaikan
in order for the development at the realistic computational environment
that means integration of KAGRA digital system, DAQ system, NDS server etc.




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



# GUI Demonstration


**After pushing Execute running KleineWelle and showing Plot**