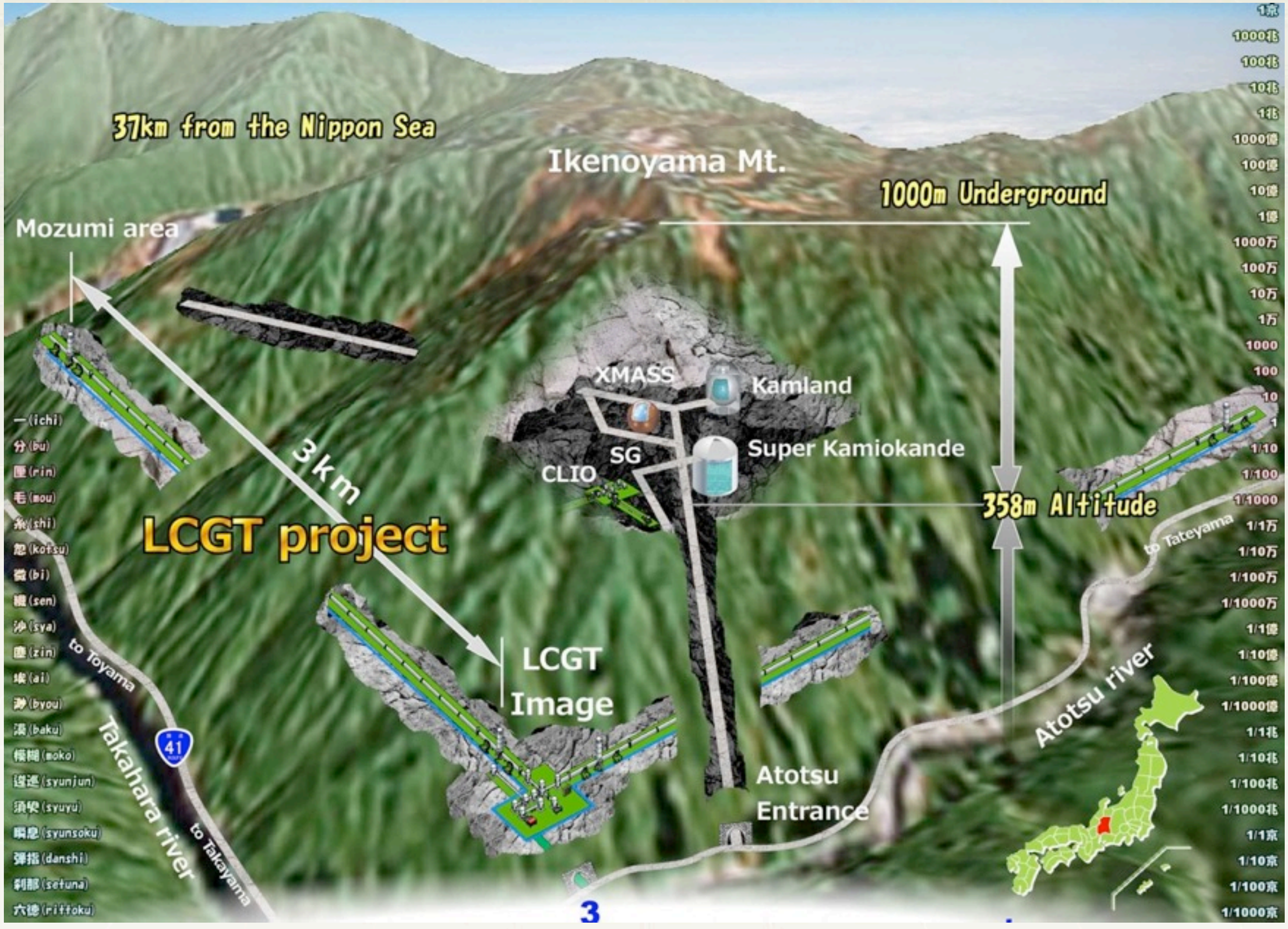
Current status of KAGRA data analysis, detector characterization

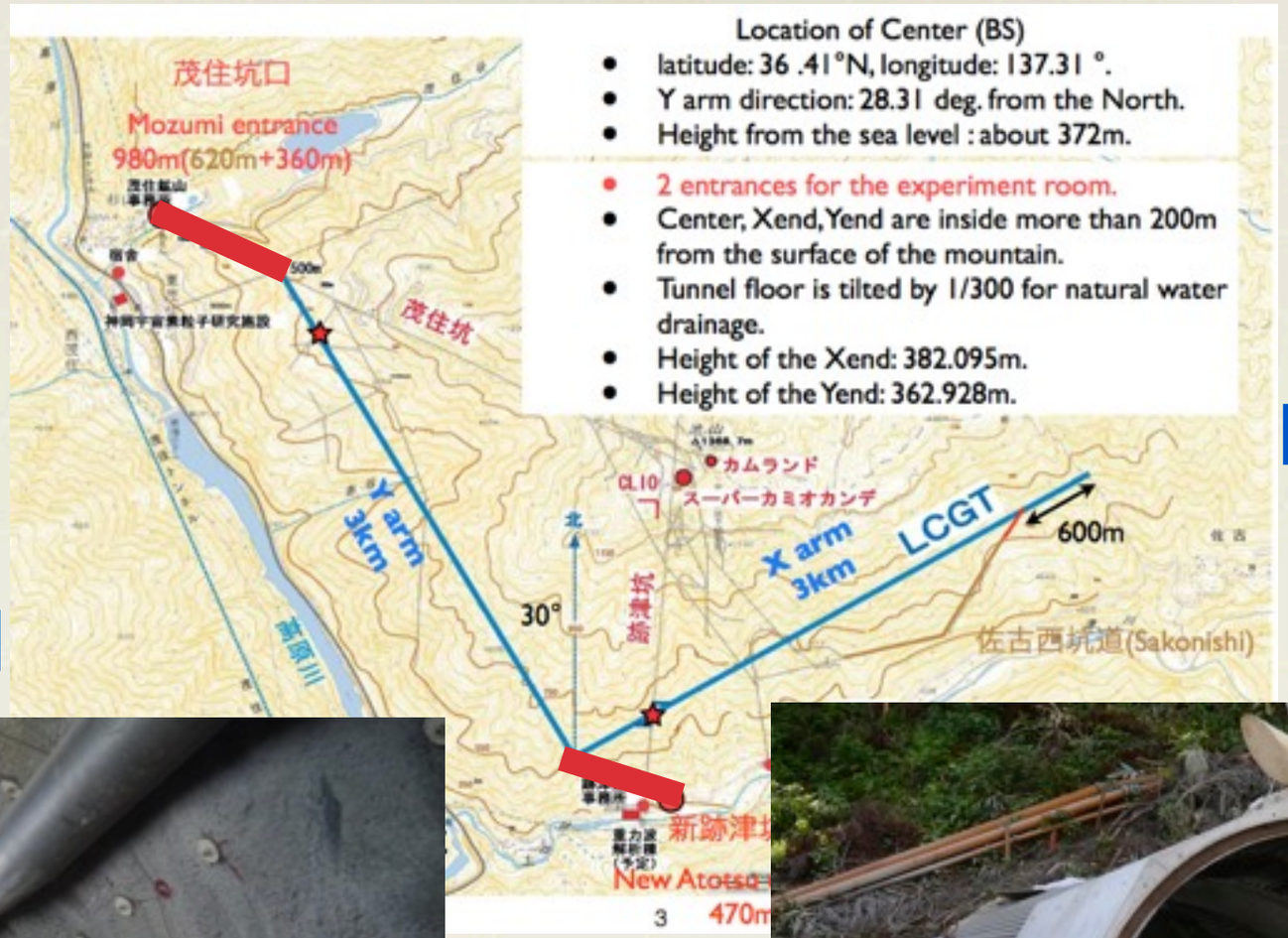
Kazuhiro Hayama (NAOJ)

KAGRA project



Start Tunnel Excavation

Nozumi 350m completed



New Atotsu 150m completed

Surface Building

Current Schedule

Calendar year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Project start									
Tunnel excavation					(~1 year delay…)				
initial-KAGRA									
					iKAGRA obs.				
baseline-KAGRA				Adv. Optics system and tests					
							Cryogenic system		
Observation									
Budget									
Leading-edge …									
Excavation									
Additional budget ?									
Budget for operation?									
Grants-in-aid for Sci.?									

Requested. We have not officially changed the schedule (yet).

Detector (not approved yet)

Data analysis (approved)

5

Kajita, f2f-July,2012

Scientific Research on Innovative Area

Binary Merger

Supernova

X, Gamma, Optical,
Infrared, radio, Neutrino,..

Multi-
Messenger

A02

Visible, Infrared

Radio

A01

Wide sky
monitor

MAXI

A03

Neutrino detection

Alart system
Multi-Messenger

A04

GW Data
Analysis

GW obs.

A05

Theory

KAGRA

Other GW telescopes

aLIGO, aVirgo

Other Astro Obs.

Satelite

Optical telescopes

Kanda, f2f-July,2012

KAGRA Data Analysis

Target GWs:

- **Compact Binary Coalescence**

  NS-NS, NS-BH, BH-BH

- **Bursts**

  Supernovae, SGR, IMBH, pulsar glitch, star quake

- **Continuous**

  Pulsar, LMXB, ...

- **Stochastic Background**

  Inflation, ...

We will develop a search pipeline for each target.

Multi-Messenger Observations

Play an important role in
- **confirmation of the first detection**
- **more science (understanding various astronomical explosions etc.)**

- **Core-collapse supernova**
  - **Neutrino, Visible, ...**
  - **SK, wide sky optical telescopes, ...**
- **Compact binary coalescence**
  - **Related to GRB? Gamma-ray, Visible, Radio, ...**
  - **MAXI, NASU radio telescopes, wide sky optical telescopes, ...**
- **SGR, pulsar glitch, ...**

Core-collapse SN

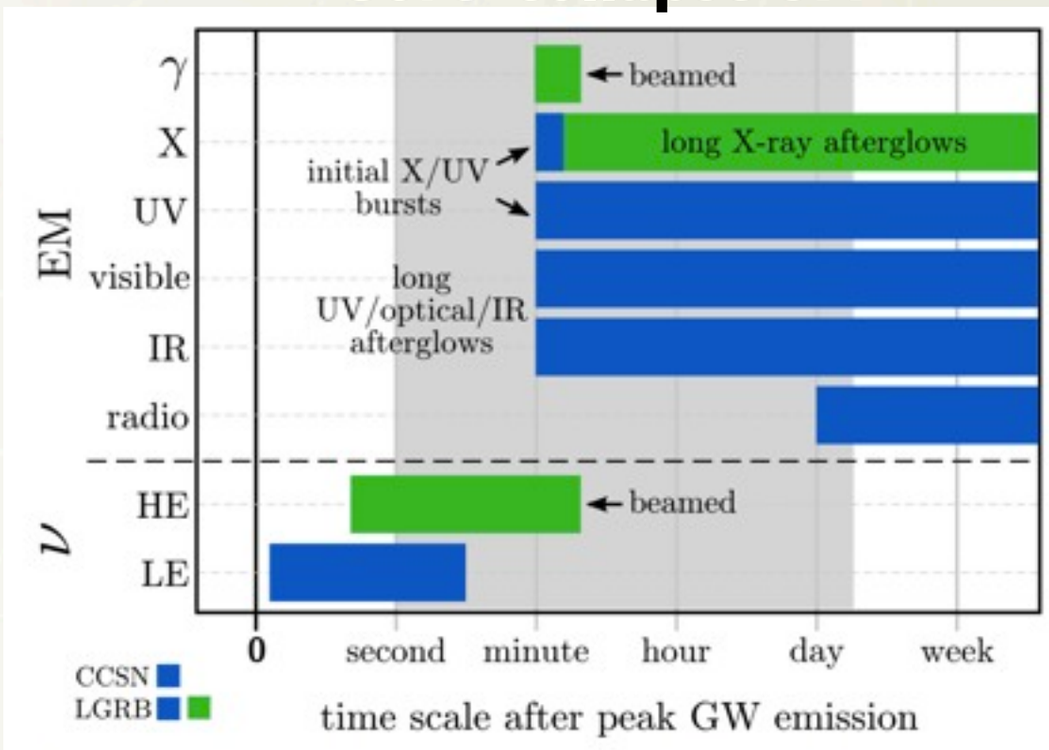


Figure 4-5: Relative arrival time of various emissions from core-collapse supernovae, as a function of time relative to peak gravitational emissions.

CBC

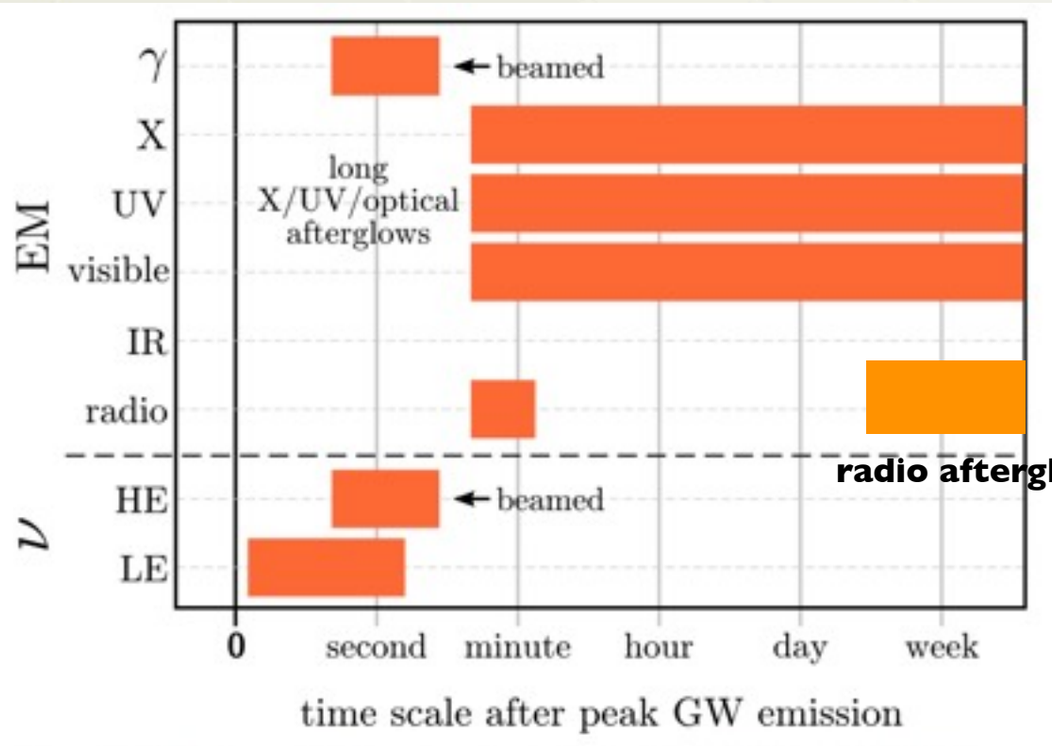


Figure 4-2: Relative arrival time of various emissions from NS-NS and NS-BH binary coalescence. Times are measured from from peak gravitational wave emissions.

Software Development

- Own search pipelines for all types of GWs

  Important for cross check, redundancy, ...

  - Single detector pipelines
  - Multiple detector pipelines
- Computation environment (GRID, ...)

MultiMessenger observation

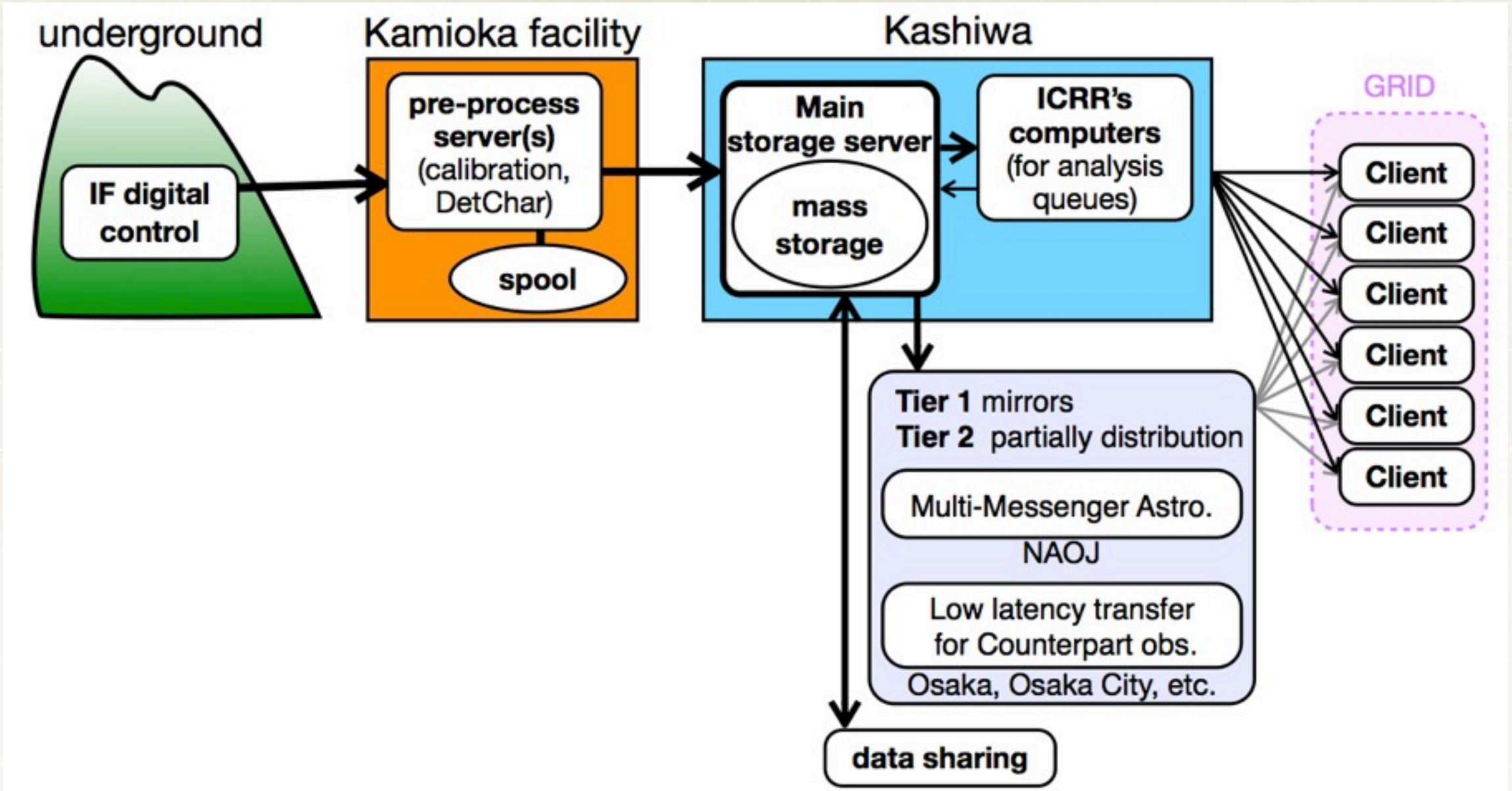
- Low-latency
  - GPGPU, parallel computing, FPGA,
- Ultra-low false alarm rate
  - Real-time Veto analysis <-- Detector characterization
  - Need new method

Data Analysis Schedule

	2012	2013	2014	2015 iKAGRA	2016	2017 bKAGRA	2018
Target	Prepare Data Analysis for 4th year			System Test	Build up full data system	Analyze Continuously Followup with Other Obs.	
Hardware	small cluster mini-system	partial system			**full system**	+ cpu, storage, peripherals	
Software	Construct common environment Implement GW search			**whole data pipeline test**			

Kanda, f2f-July,2012

Data Flow


underground
Kamioka facility
Kashiwa
IF digital control
pre-process server(s) (calibration, DetChar)
spool
Main storage server
mass storage
ICRR's computers (for analysis queues)
GRID
Client
Client
Client
Client
Client
Client
Tier 1 mirrors
Tier 2 partially distribution
Multi-Messenger Astro.
NAOJ
Low latency transfer for Counterpart obs.
Osaka, Osaka City, etc.
data sharing

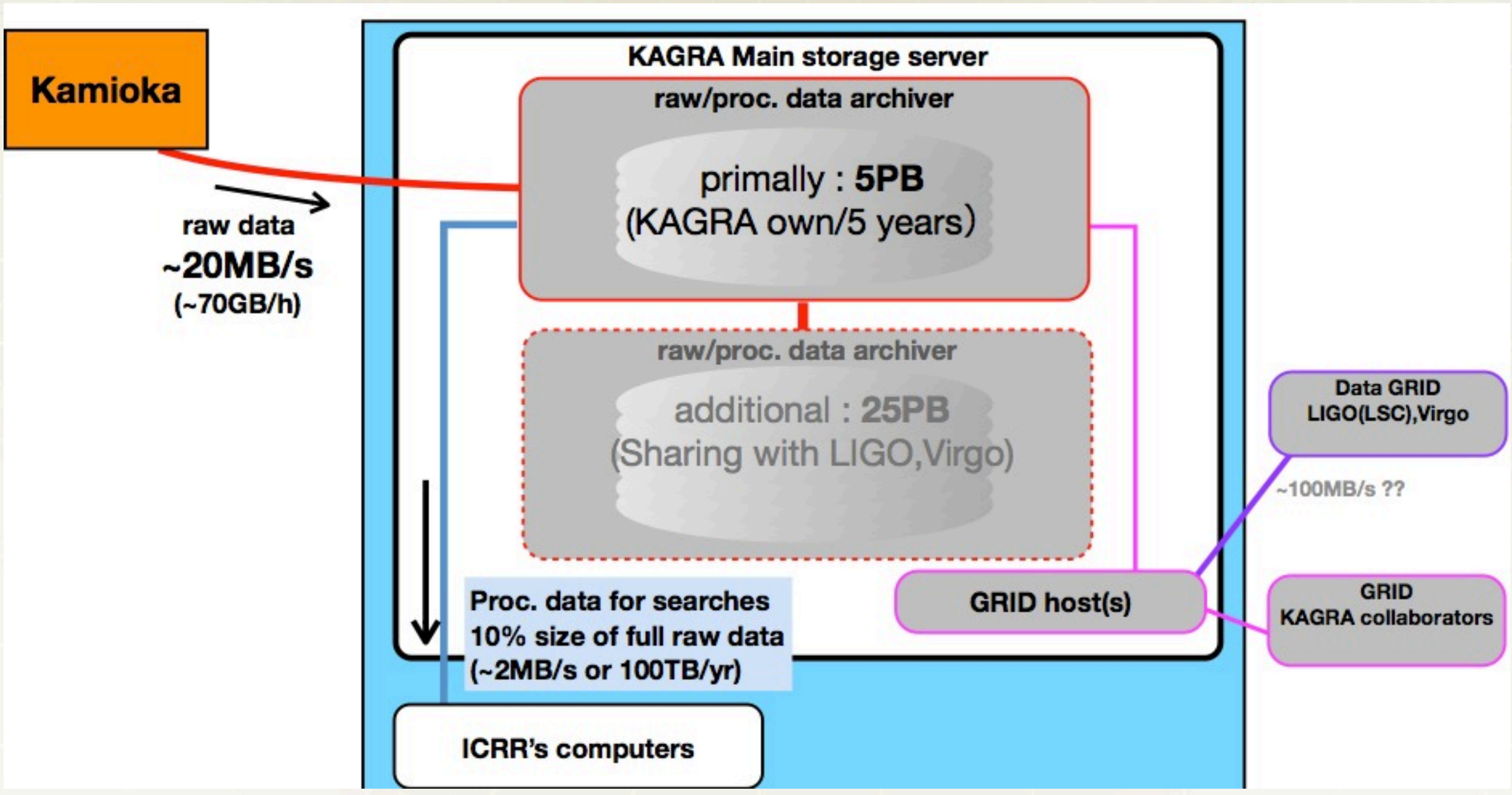
Requirement of Analysis System

item		*requirements*
Network and Pre-process throughput		**~70 GB/hour**
Storage	two weeks safety spool	25 TB
	on site study	**500 TB**
	KAGRA own	**5 PB for 5 years**
	Data Sharing	**30 PB for 5-sites**
Calculation costs for GW searches	Compact Binary	**a few ~ several Tflops**
	Burst	**~1 Tflops**
	Continuous	**~1 Tflops**
	Stochastic	**< 1 Tflops**
Software	Search pipeline	need development, migration from LV, GRID system
	Environment	

Blue: iKAGRA, Red: bKAGRA

Kanda, f2f-July,2012

Designed Storage Server



Detector Characterization

- **Evaluation of data quality**
  - **Determine which data segment is available for science.**
- **Support diagnostics: --> help to shorten the commissioning period finding non-stationary components, artificial lines in channels. It will help to kill noise sources before KAGRA observing.**
- **Distribution of Veto information**
- **The unique information of KAGRA should be taken care within detchar so that other collaborators are not concerned about it to some extent.**

Human Resources

- **Chief: Kazuhiro Hayama**
- **Other Chiefs: Araya(GIF), Miyakawa(DGS), Aso(MIF), Kanda (DAS), Somiya(SEO)**
- **Staffs: Kokeyama(LIGO Livingston), Agatsuma(NAOJ),**
- **Students: Yamamoto, Yuzurihara, Tanaka**

Most of them are not fully assigned to this group. We need active participants.

Interfaces

KAGRA GW telescope

PEM, Aux. channels, Online-monitors, diagnostics

Detector Characterization

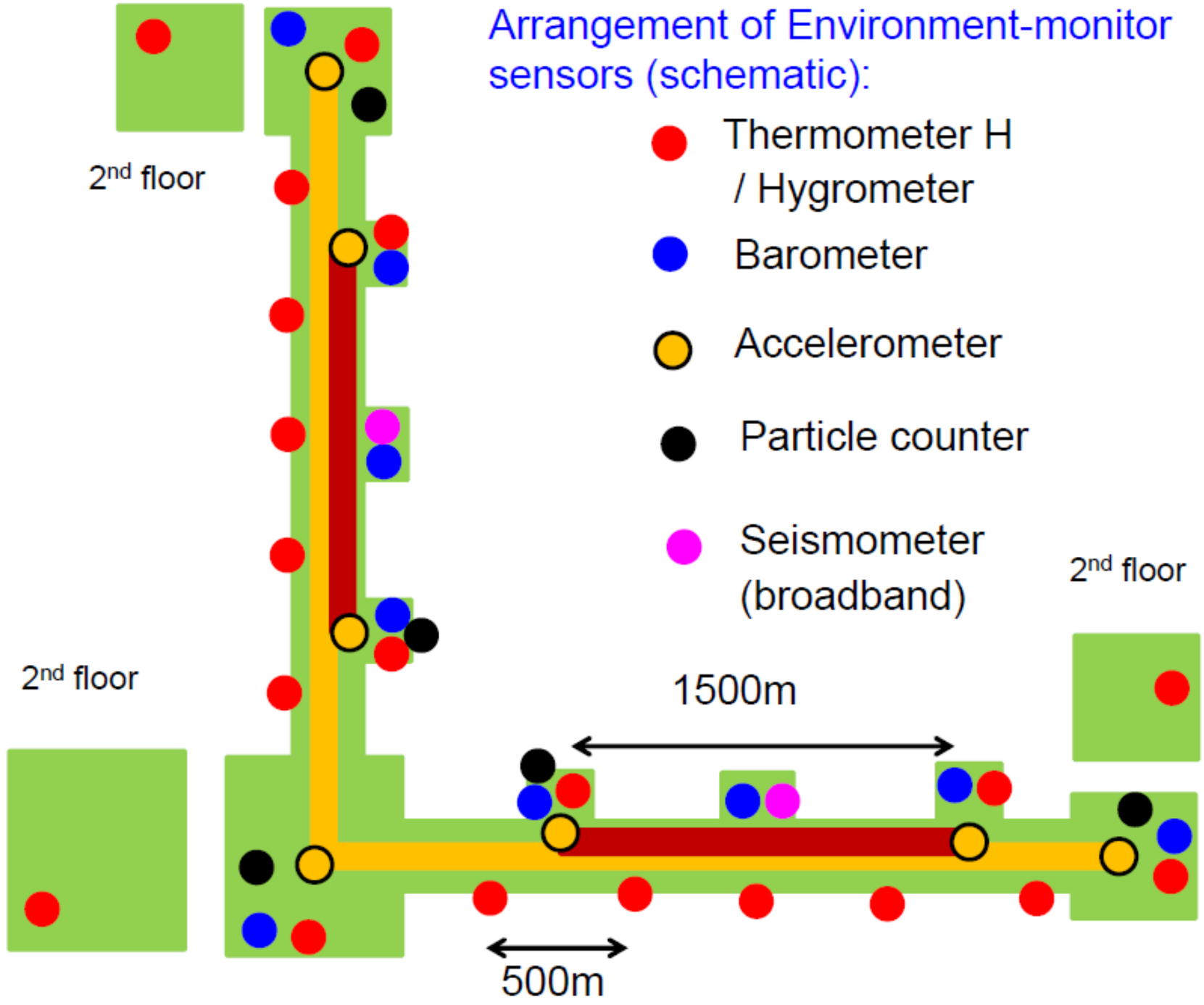
Veto info, target veto, Data quality, calibration accuracy

Data Analysis

- **Channels: Interfaced with many subsystems**

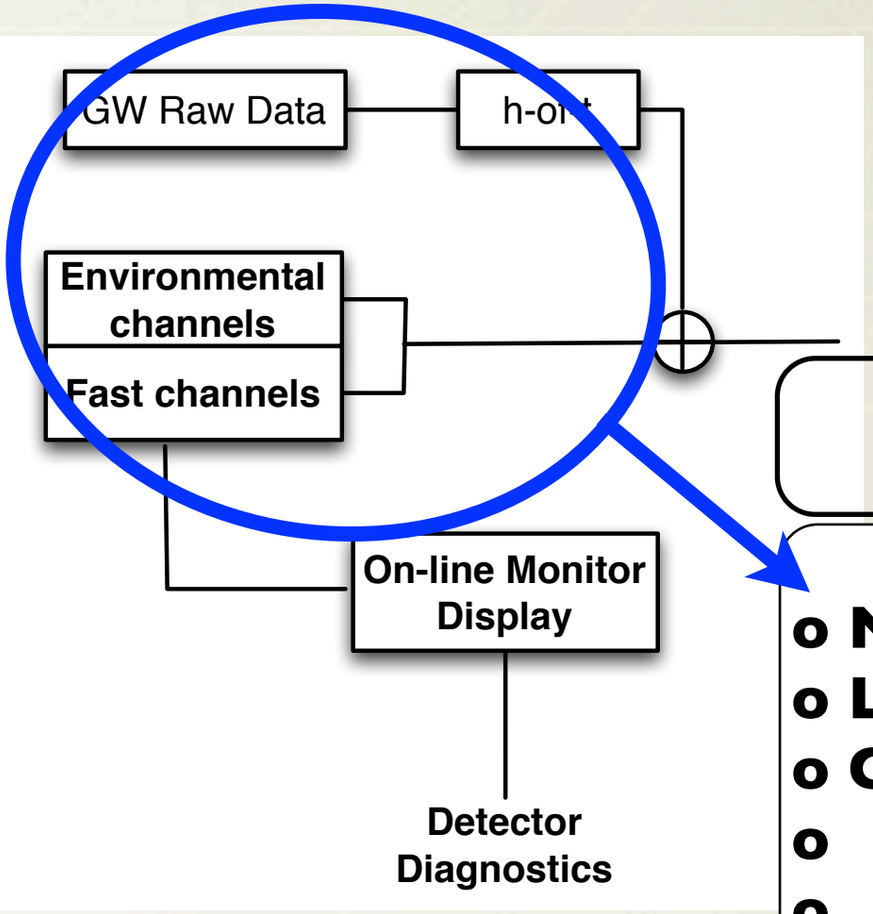
Physics and Environmental Monitor

Arrangement of Environment-monitor sensors (schematic):



Araya, f2f-July,2012

Detchar Base System

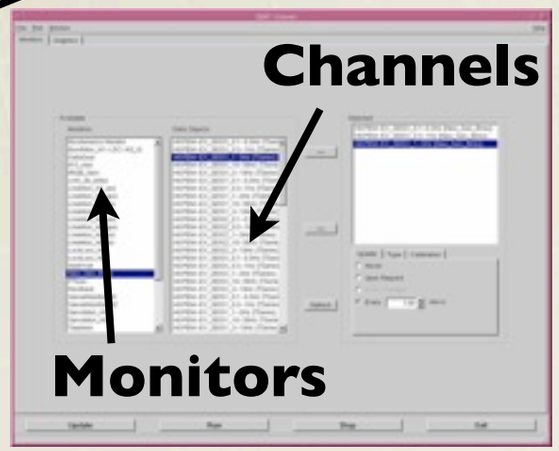


Announce its running

Server

Monitors

- o NoiseFloorMon
- o LineMon
- o GlitchMon
- o
- o
- .....



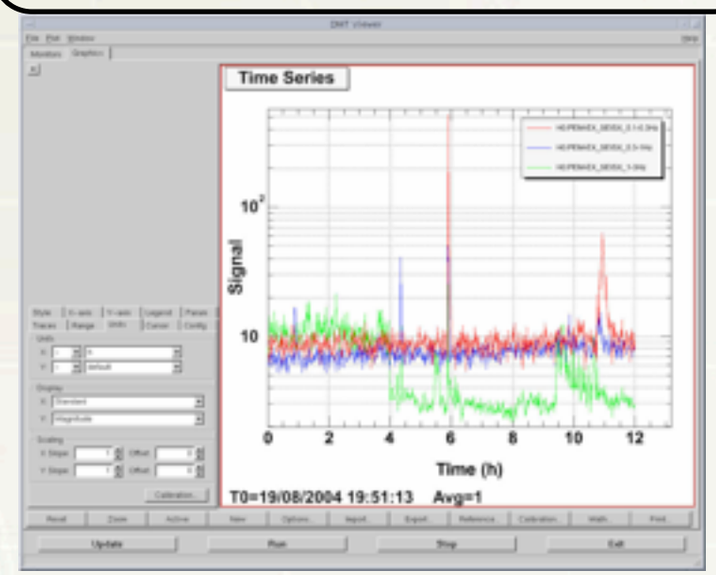
Monitors ?
Channels ?

Monitors
Channels
Available

Request Data

Data

Viewer

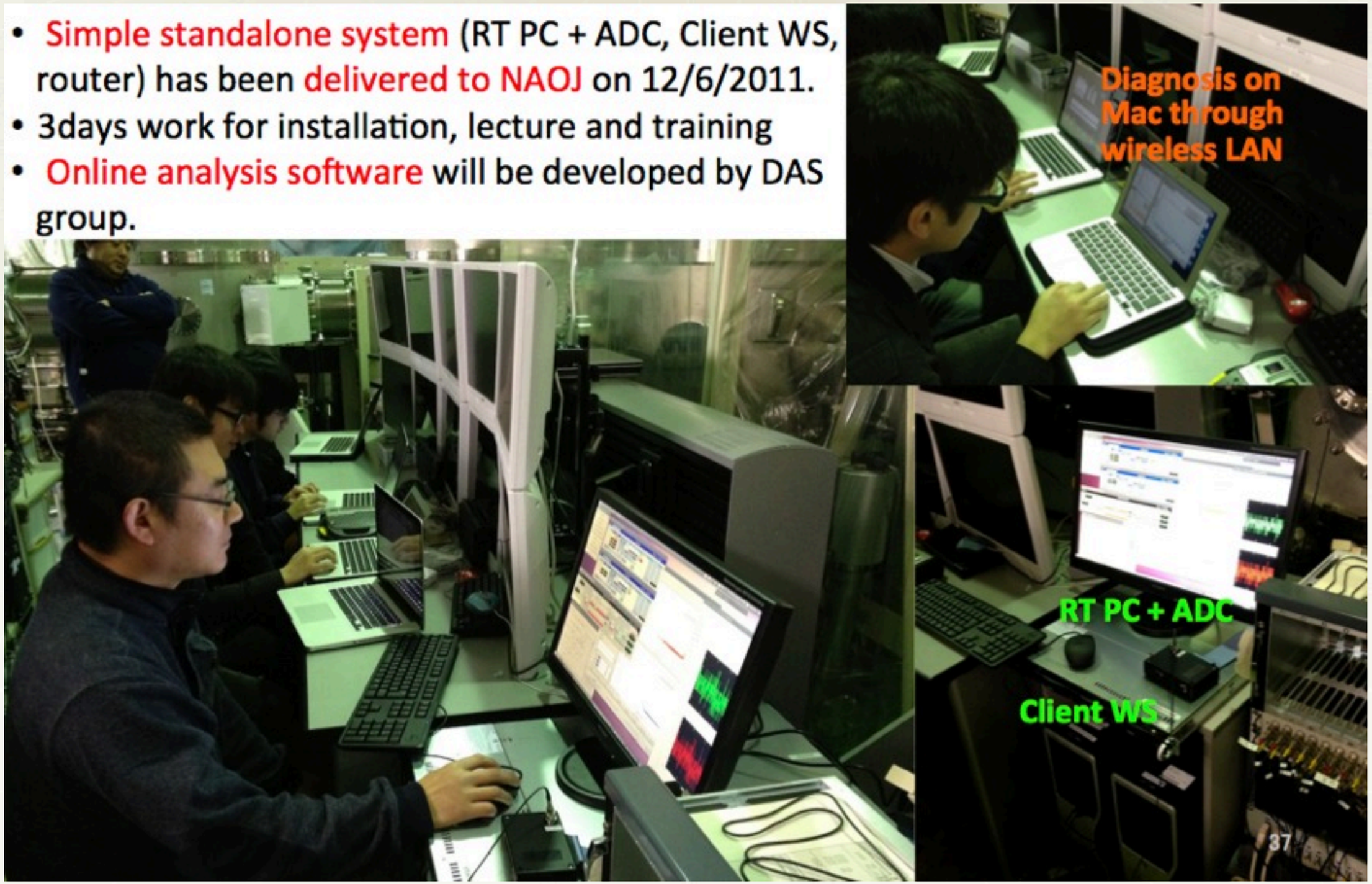


- Through viewer, one can see plots from remotely.
- Developing monitors and contribute to other collaborations.

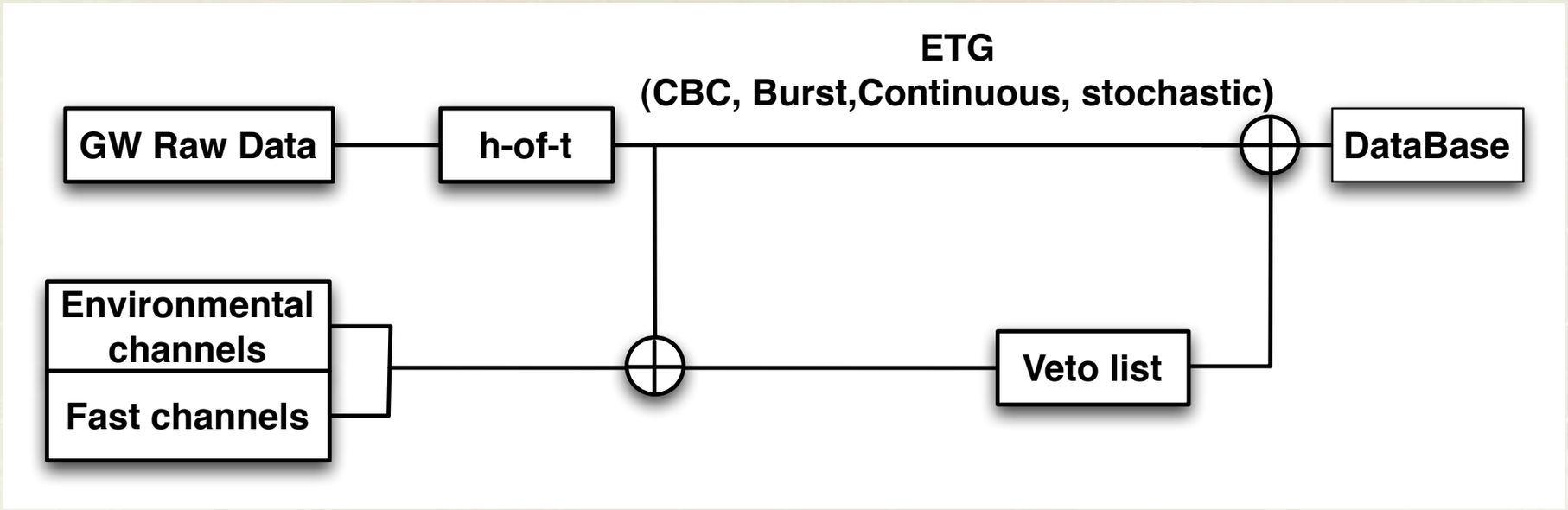
KAGRA Developing the system on digital at NAOJ

Hayama(NAOJ), Miyakawa(ICRR), Yamamoto, Yuzurihara(OCU), Susa(Titech), Dan (UT)

- Simple standalone system (RT PC + ADC, Client WS, router) has been delivered to NAOJ on 12/6/2011.
- 3days work for installation, lecture and training
- Online analysis software will be developed by DAS group.



For Event Searches



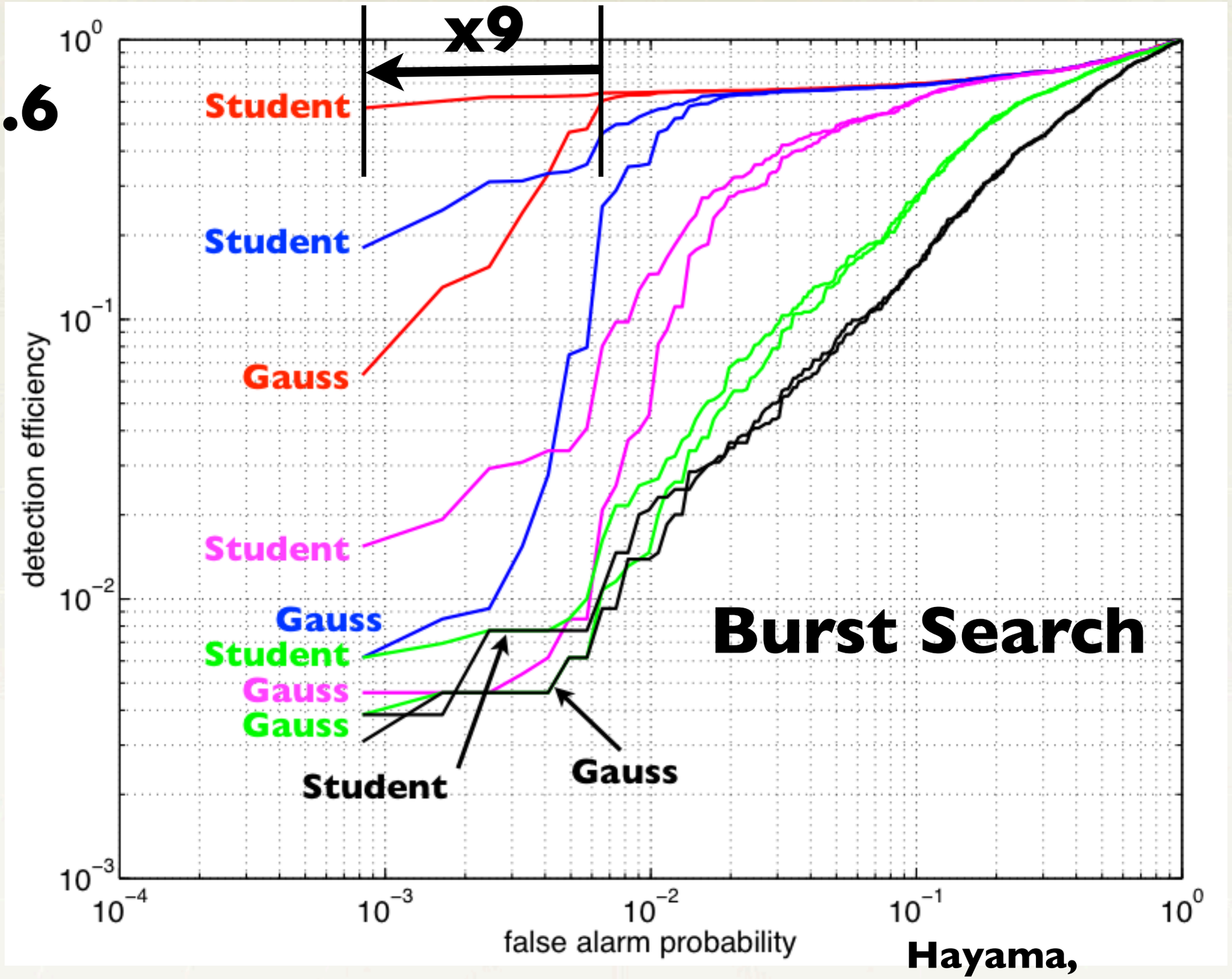
Veto list generation

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 • ...

Software Development

- **Import of LVC software**
  - **Data quality monitor (Not all, but some)**
  - **Glitch detection pipeline (Several pipelines, need sophistication in progress.)**
  - **Coincidence analysis pipeline <- collaboration with UTB**
- **New software requirement / sophistication**
  - **Noise modeling (power spectrum and, probably, glitch) (New method developed. Next slide)**
  - **Multivariate analysis <- collaboration with Korea GW.**
  - **Glitch classification (One paper accepted.)**

New Noise Modeling



Hayama,
paper submission ready

END

DetChar Schedule

I. **Prototype test in CLIO**
- o Installation test of detchar basic system at NAOJ.
- o Test operation of detchar basic system during CLIO operation.
- o Software development.

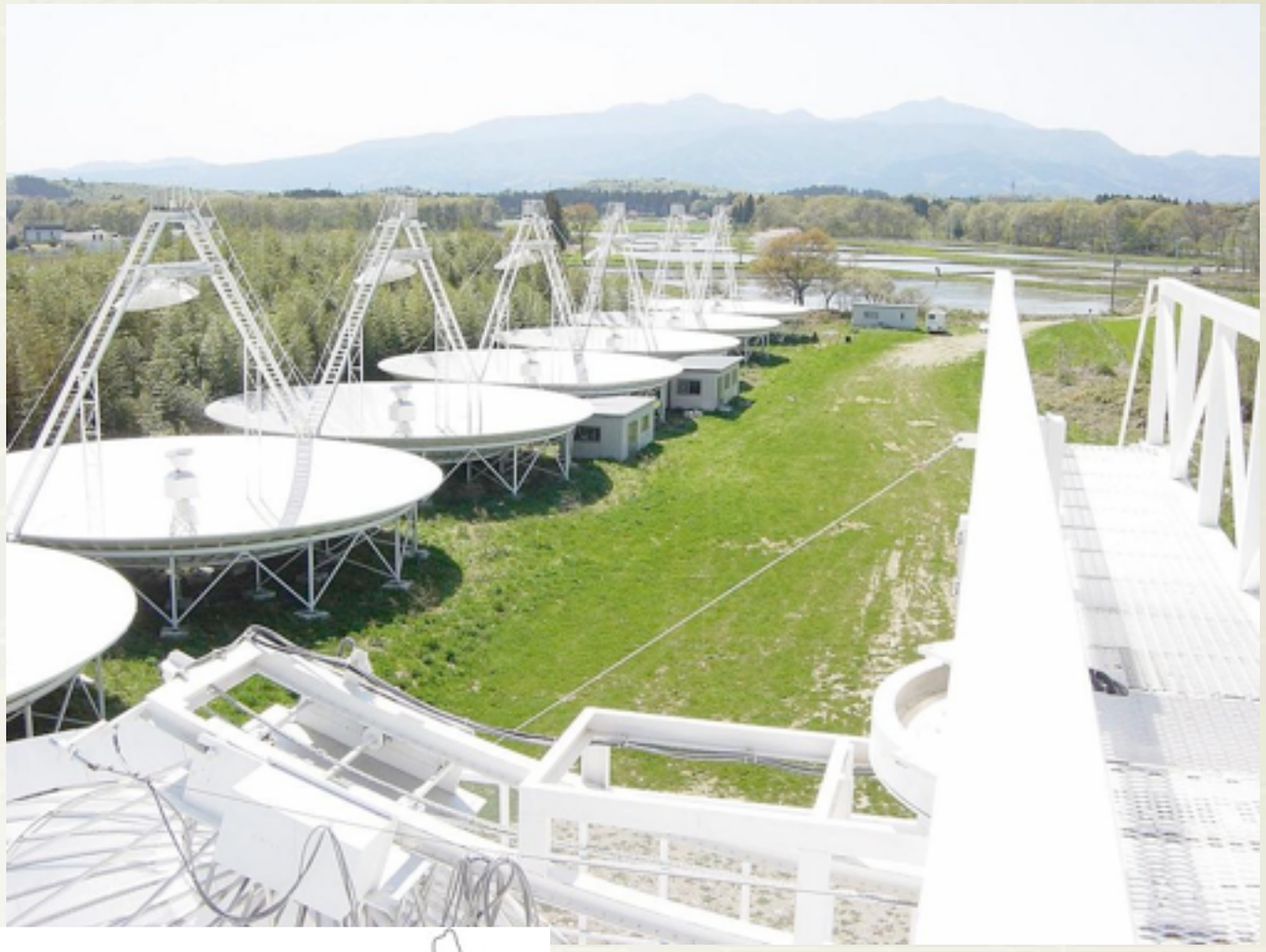
Will do ~this fall.

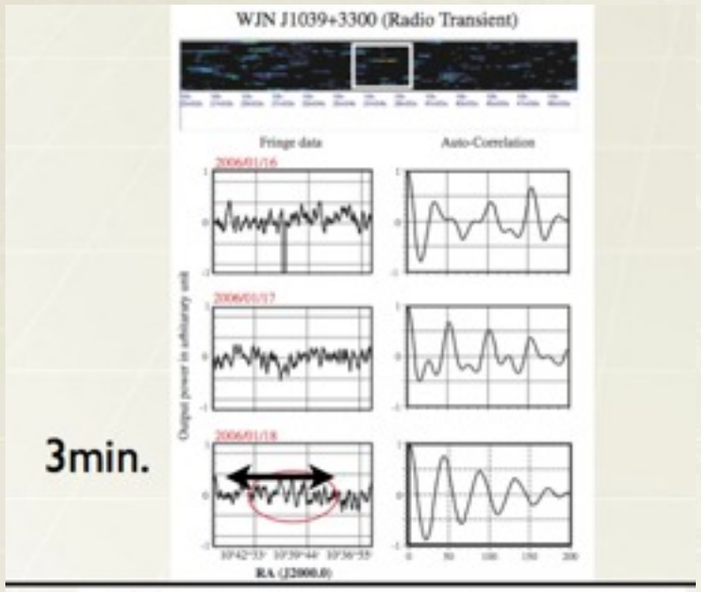
II. **Computation platform**
- o 2Q-4Q2014: Implementation of detchar system in a pre-process server.
- o 1Q-3Q2015: Installation of the pre-process server to a building.

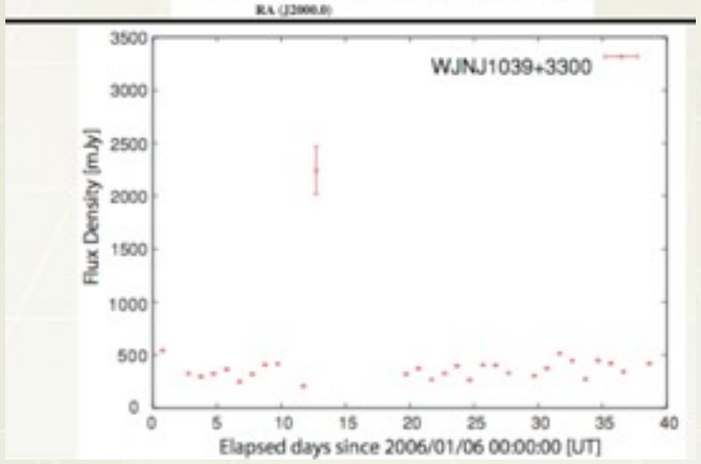
III. **Test operation**
- o Operation of the detchar system during GIF operation from ~ June, 2015.
- o Operation during iKAGRA in ~ Nov. 2015.
- o Software development

IV. **Operation**
- o Operation during bKAGRA from ~ Aug. 2018.

Nasu radio telescope-GW detectors







- **Looking for radio transients**
- **The optimal observation frequency(1.4GHz) for the radio afterglow from CGC**
- **11 radio transients detected so far, source is unknown.**
- **Project Nasu-LIGO, Nasu-TAMA analysis is in going.**