Commissioning work on the low temperature interferometer

5/17/2010 GWADW at Kyoto

Osamu Miyakawa (ICRR, U-Tokyo) and CLIO collaboration

Simple, compact interferometer for cryogenic

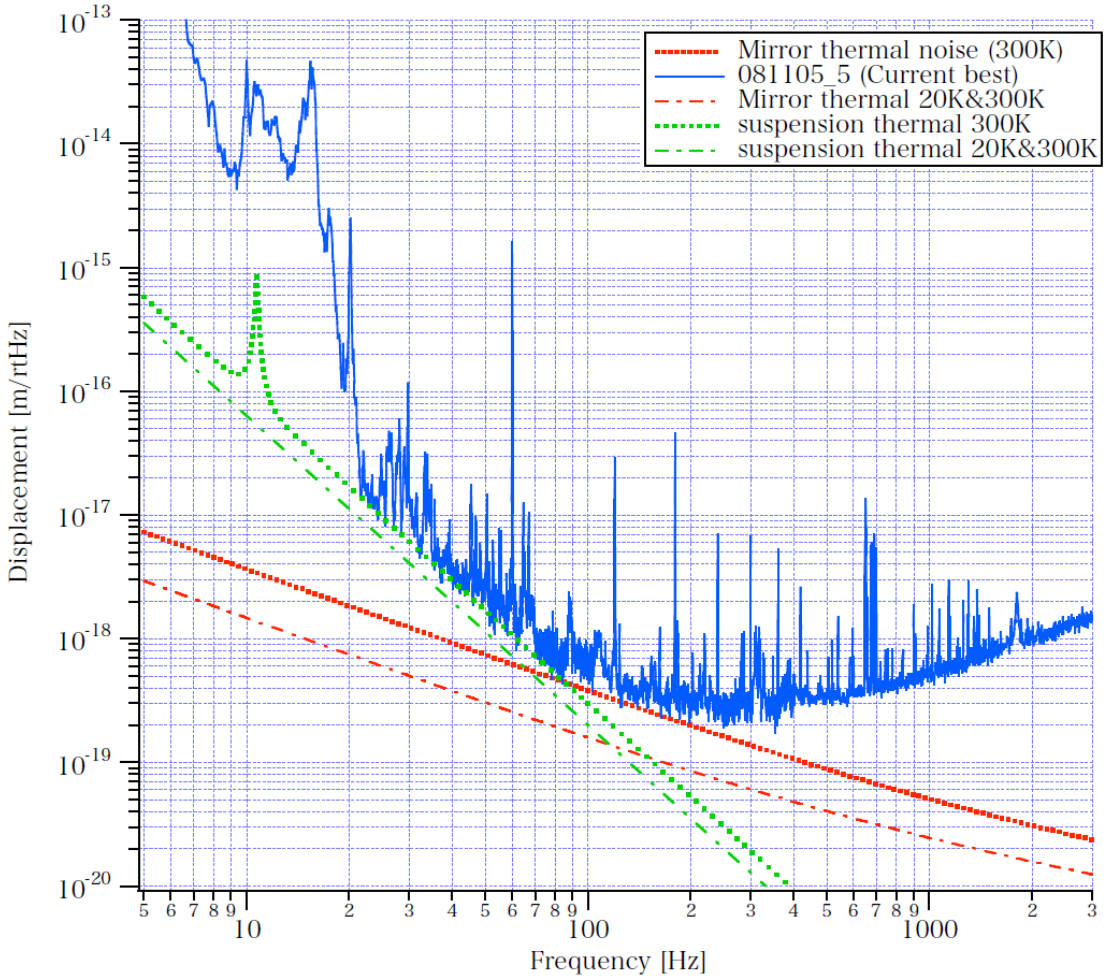
- CLIO is a 100m scale prototype interferometer.
- Simple optical configuration known as Locked-FP style (similar to old 40m in Mark II era) for independent DOFs.
- Quite simple analog circuits, a very few monitors (view ports, CCDs)

- Simple configuration is not a bad idea to identify noise sources, especially for low temperature experiment.

But, less flexibility, in fact…

- Today's talk is with
  - Some curious experiences on low temperature interferometer experiment,
  - To have more flexibility with a digital control being installed

Expected sensitivity by cooling two front mirrors



- **Thermoelastic noise is inversely proportional to radius of beam, so front mirror is more effective for cooling.**

- **Replace thick amorphous fibers used in room temperature to 99.999%, d=0.5mm pure aluminum fibers**
  - **Q on table top = 7000 @ 4K.**
  - **Expected Q in CLIO = 4.85e4 (provides enough low thermal noise)**
- **Final design: to be replaced to sapphire fibers**

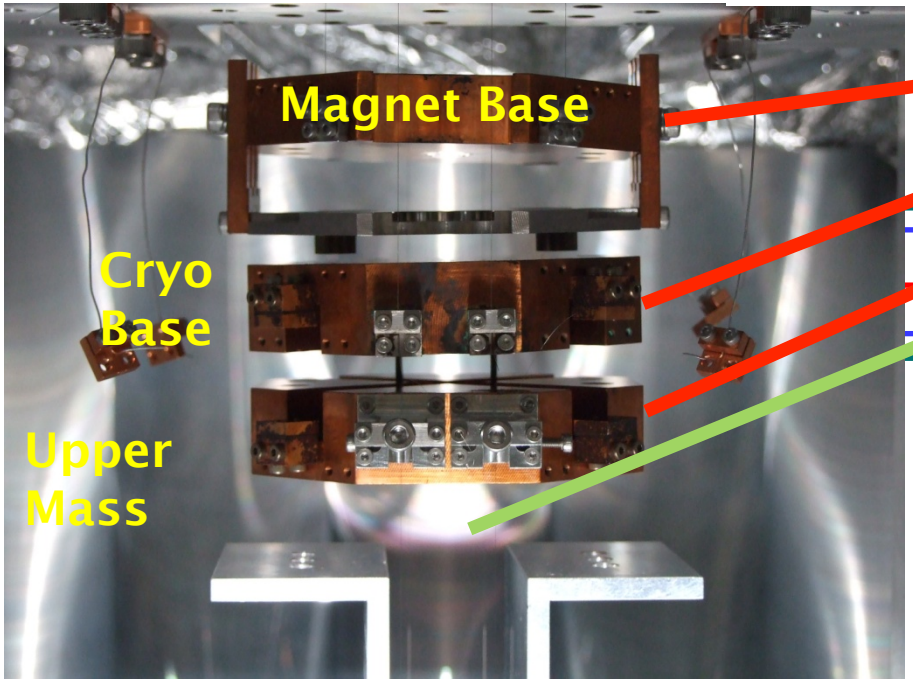
How to cool

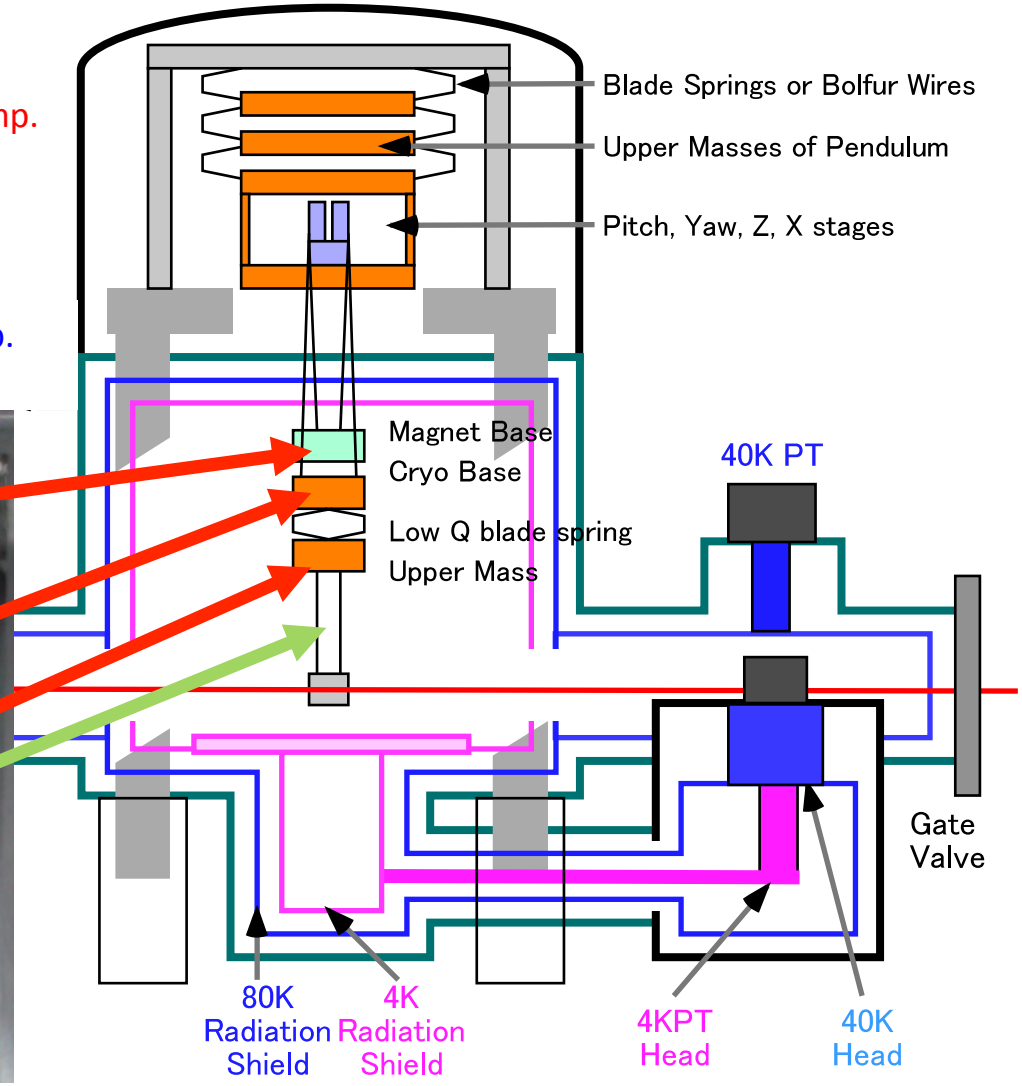
●3 heat links between:
①Magnet Base and inner shield; 15cm
②CryoBase and inner shield; 31.5cm
③CryoBaseand and UpperMass; 11.5cm
φ0.5mm pure aluminum wire

•It takes 7-10day to be cooled down.

Room temp. part

Low temp. part



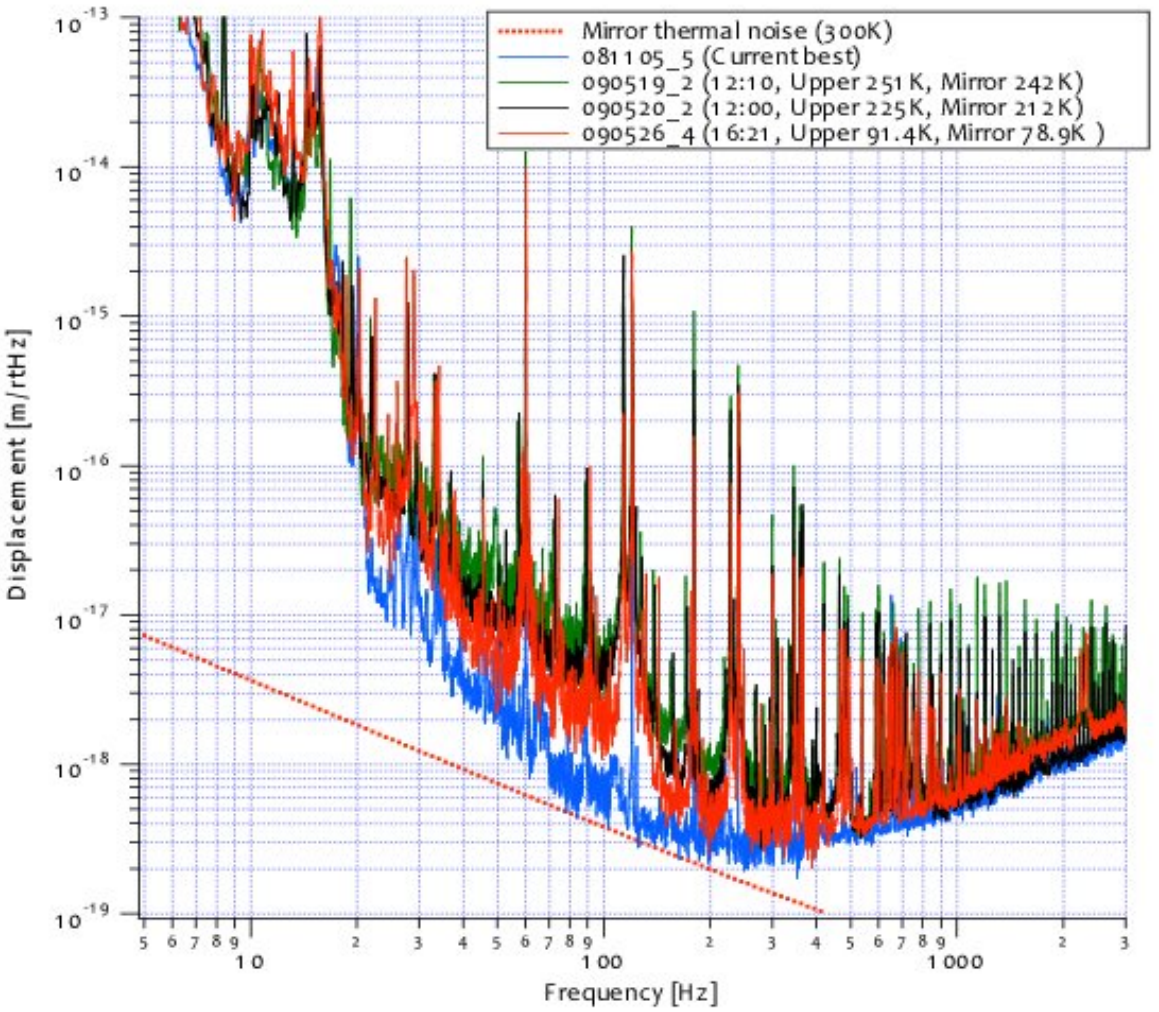


Low temperature experiment

•Suspension thermal noise was reduced, as the aluminum wires were cooled;

1. 242K 5/19/2009
2. 212K 5/20/2009
3. 79K 5/26/2009

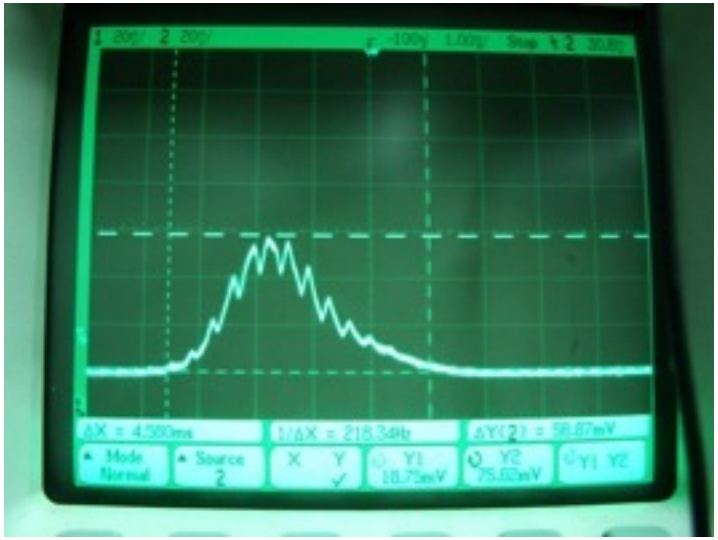
•A big jump from 212K to 79K, because of too much creaks when structures were shrinking to measure noise. Creaks vanished below 100K.



Troubles in low temperature

- Very small leakage of air is not a critical problem in room temperature, but a critical problem in low temperature as contaminations on the mirror shown as change cavity reflectivity and transmissivity, and noisier above 1kHz
- Needed a careful check for O-ring, gate valve with a leak detector.

- Cavity with a pair of Low temp. mirror – room temp. mirror generates non-stationary, msec order noise. We guess that particles from room temperature area hit low temperature mirror.



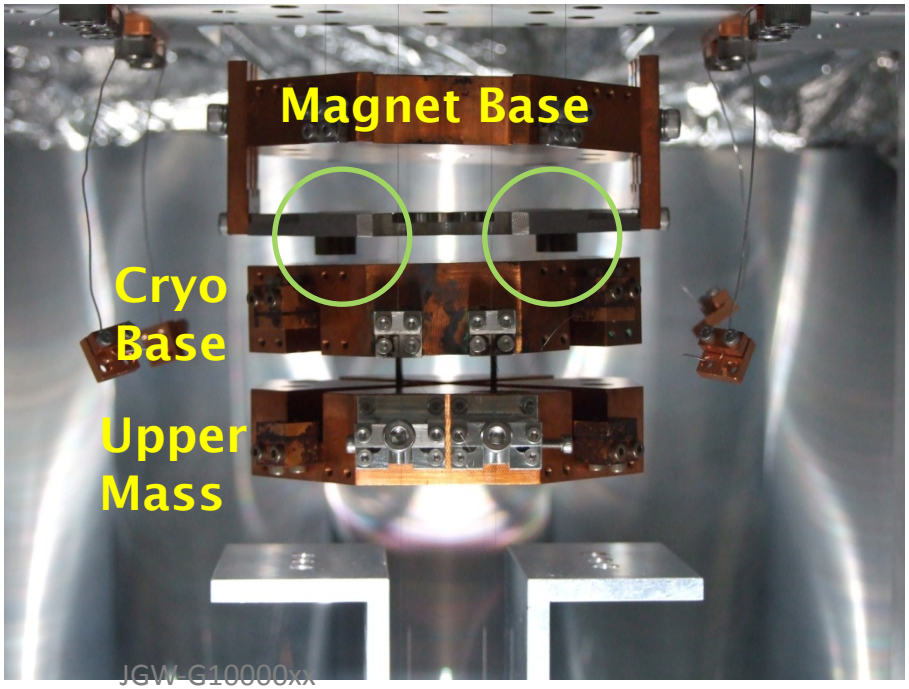
Over eddy current damping

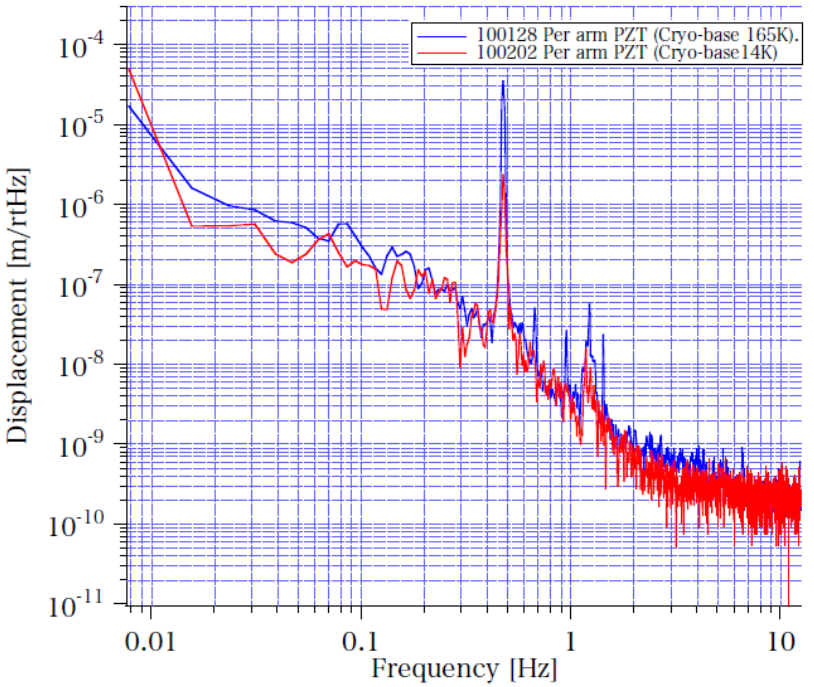
Problem:

Over eddy current damping between Magnet Base and Cryo-Base in low temperature, because they move combinedly by too strong damping since the lower resistance by lower temperature

Solution: Smaller magnets to reduce damping force

Q~1000 in room temperature, Q~30 in low temperature



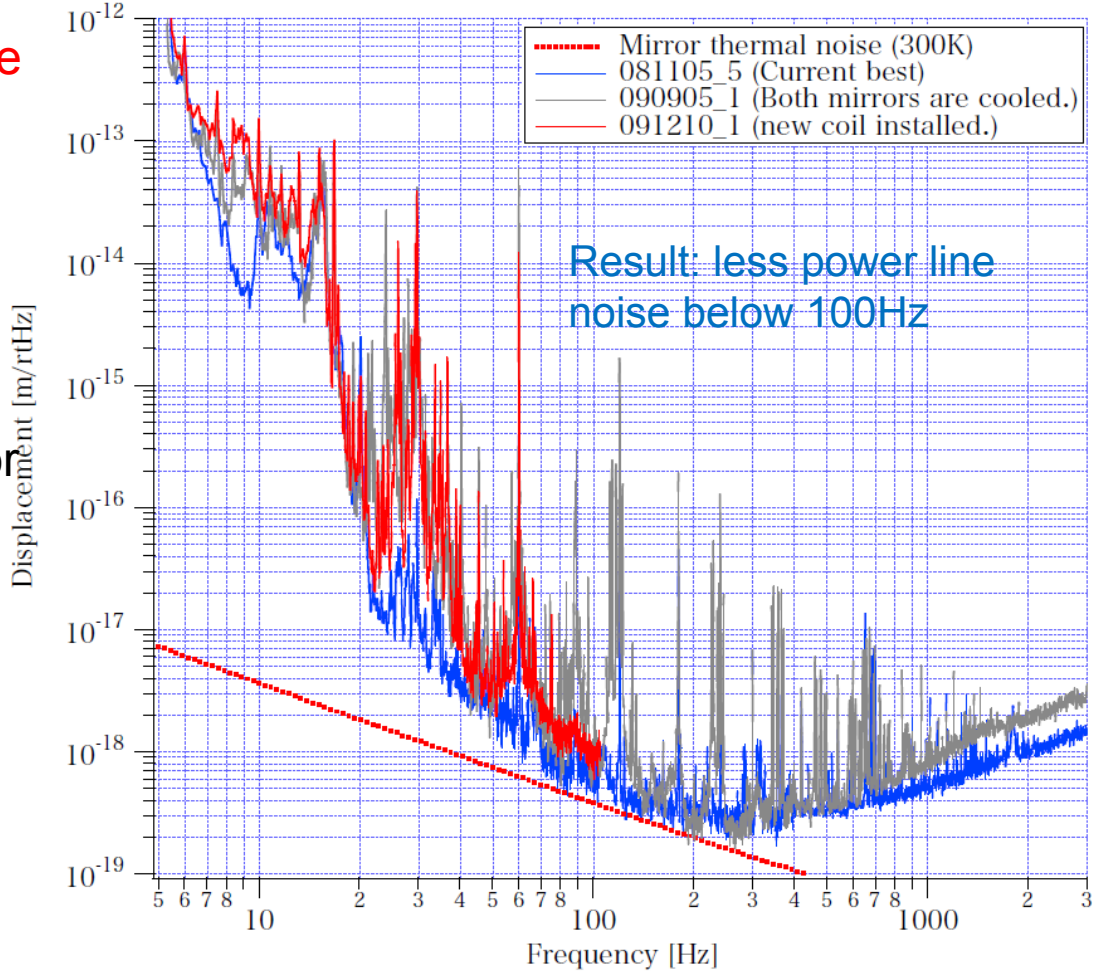


Reduced power line noise

Problem: too many power line noise for the small number of heat links

Guess:
Dependence of electrical resistance on coil wire increases the coupling between coil wire and magnet attached on the main mirror by lower temperature, and seismic motion of the coils transmits main mirrors directly.

Solution:
Replaced coil wire to phosphor bronze which has less resistance dependence on temperature.



Results on cooling experiment are shown at
Takashi Uchiyama's talk on tomorrow morning session.

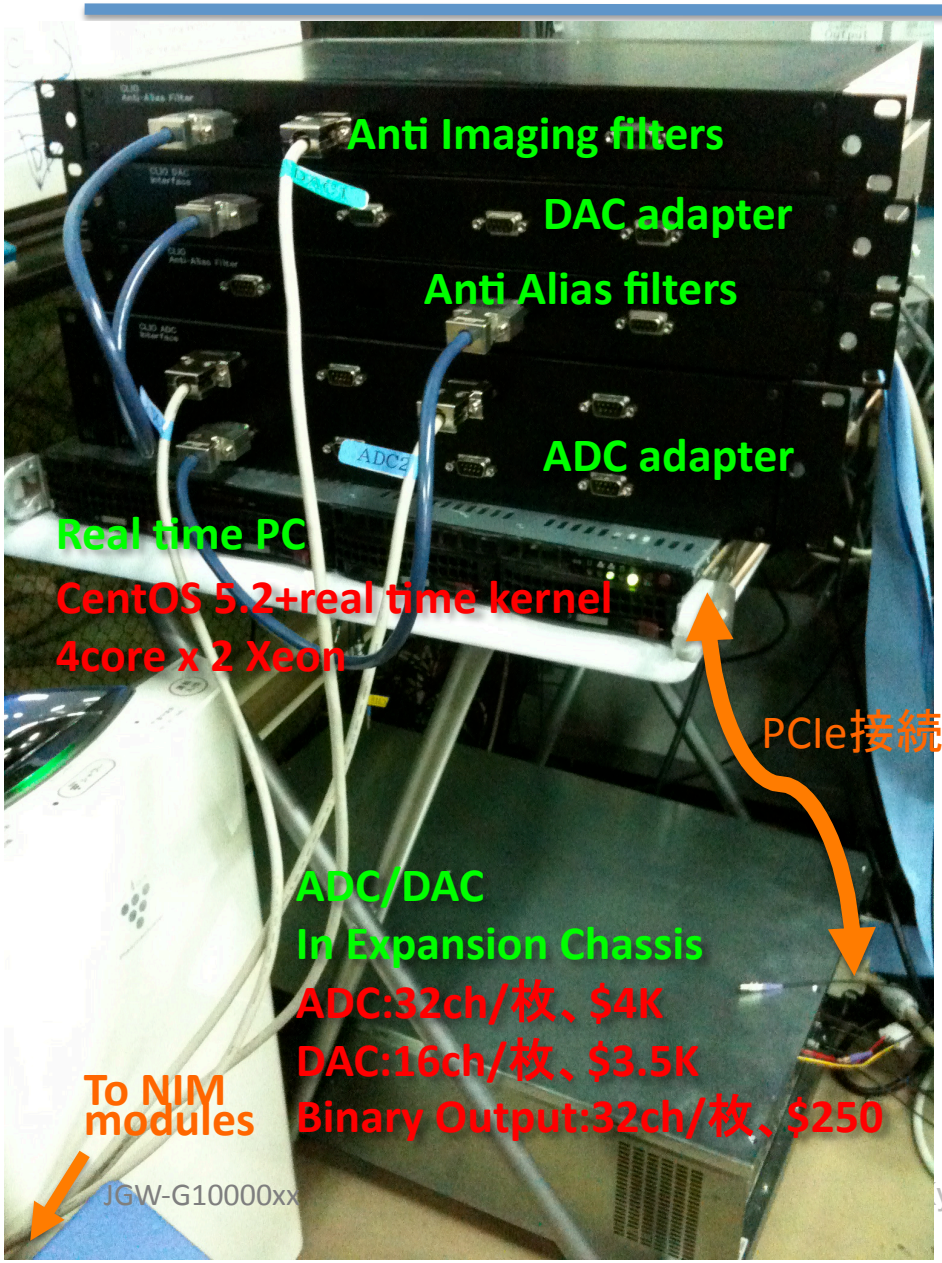
Possibility of a digital control system

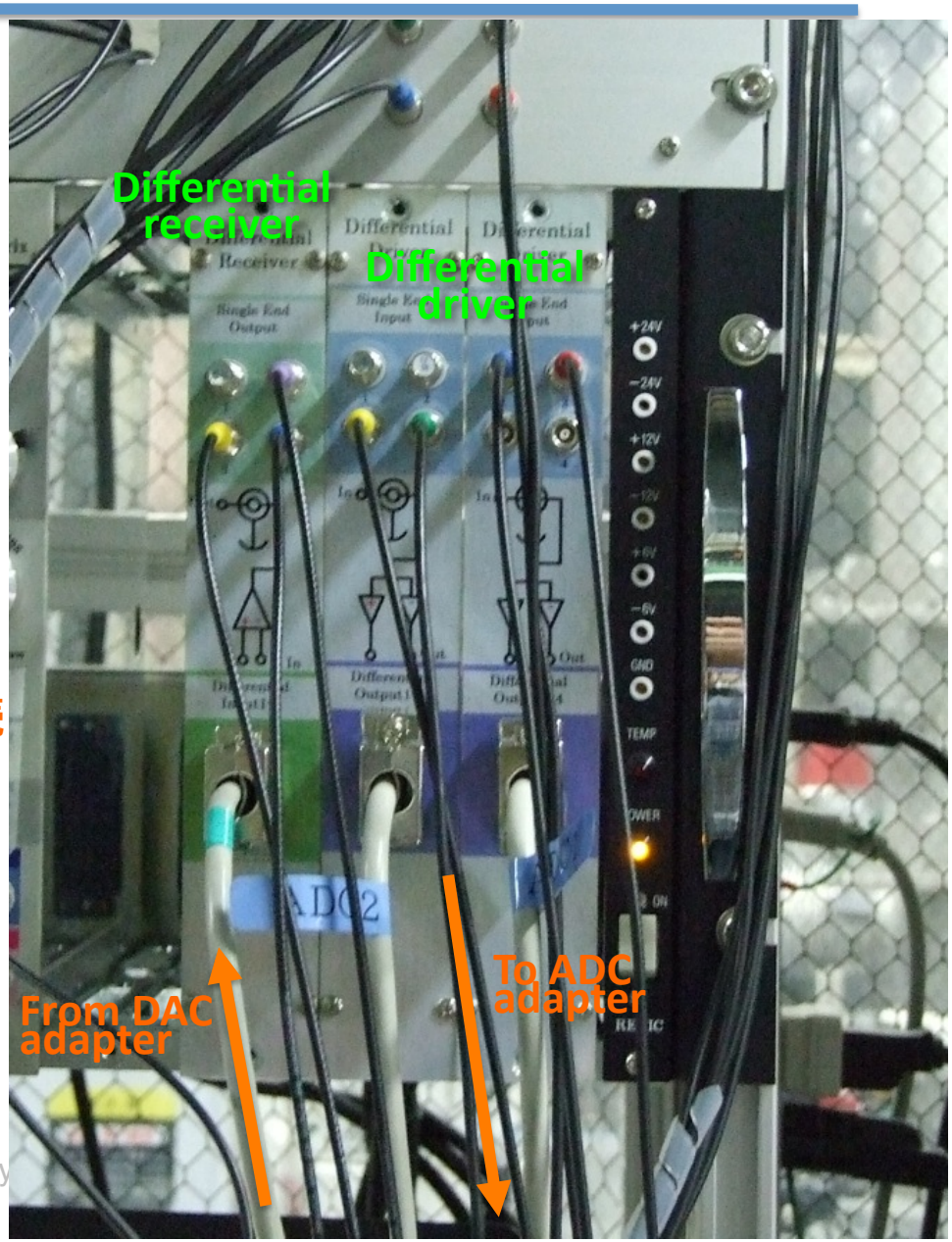
1. Increased the number of person 1->4 at site
2. Scheduled commissioning plan
3. Flexibility
4. As a prototype of LCGT

Installation of a digital system at CLIO with help of aLIGO engineers

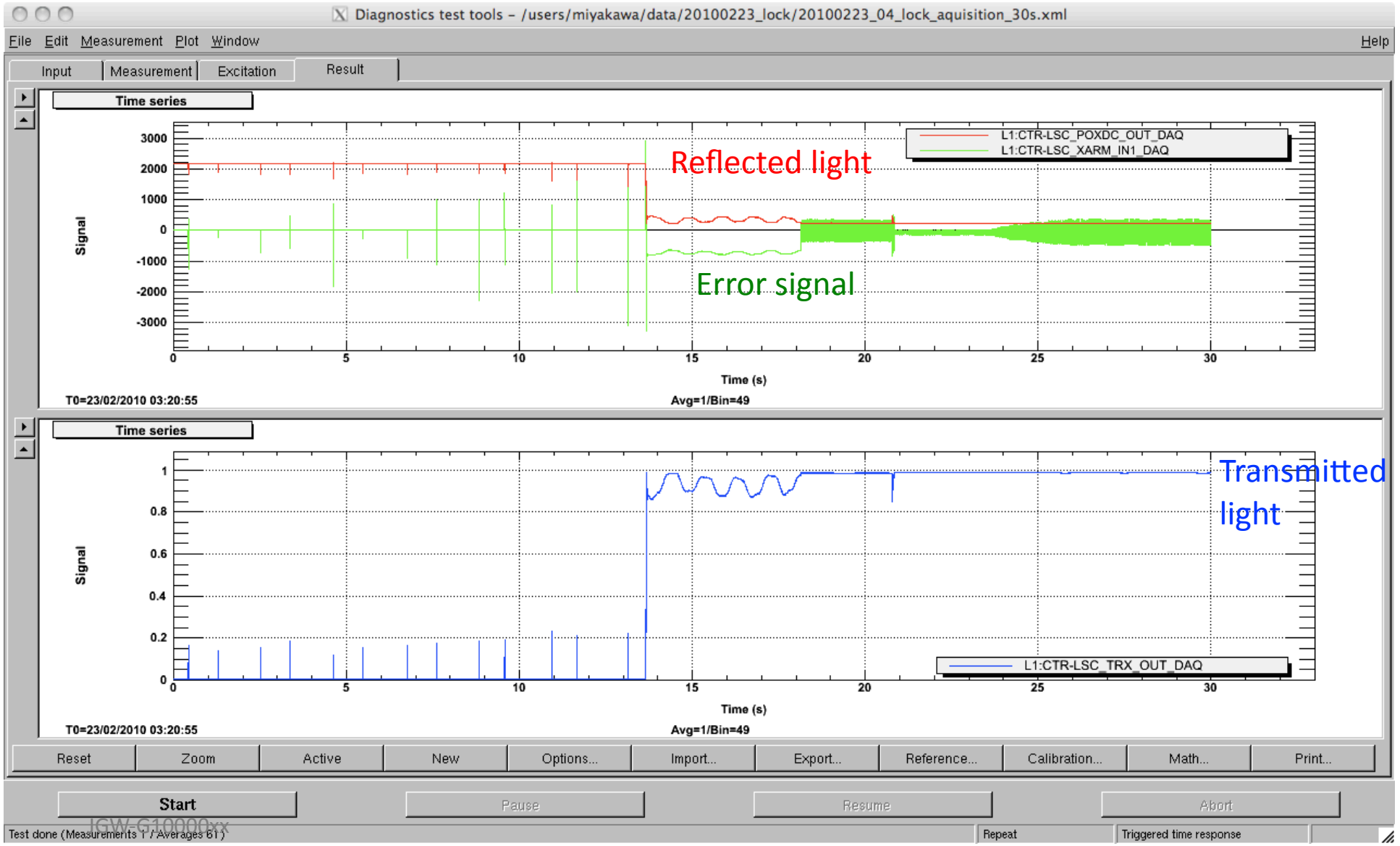
->Shrink the time for noise hunting!

Pictures

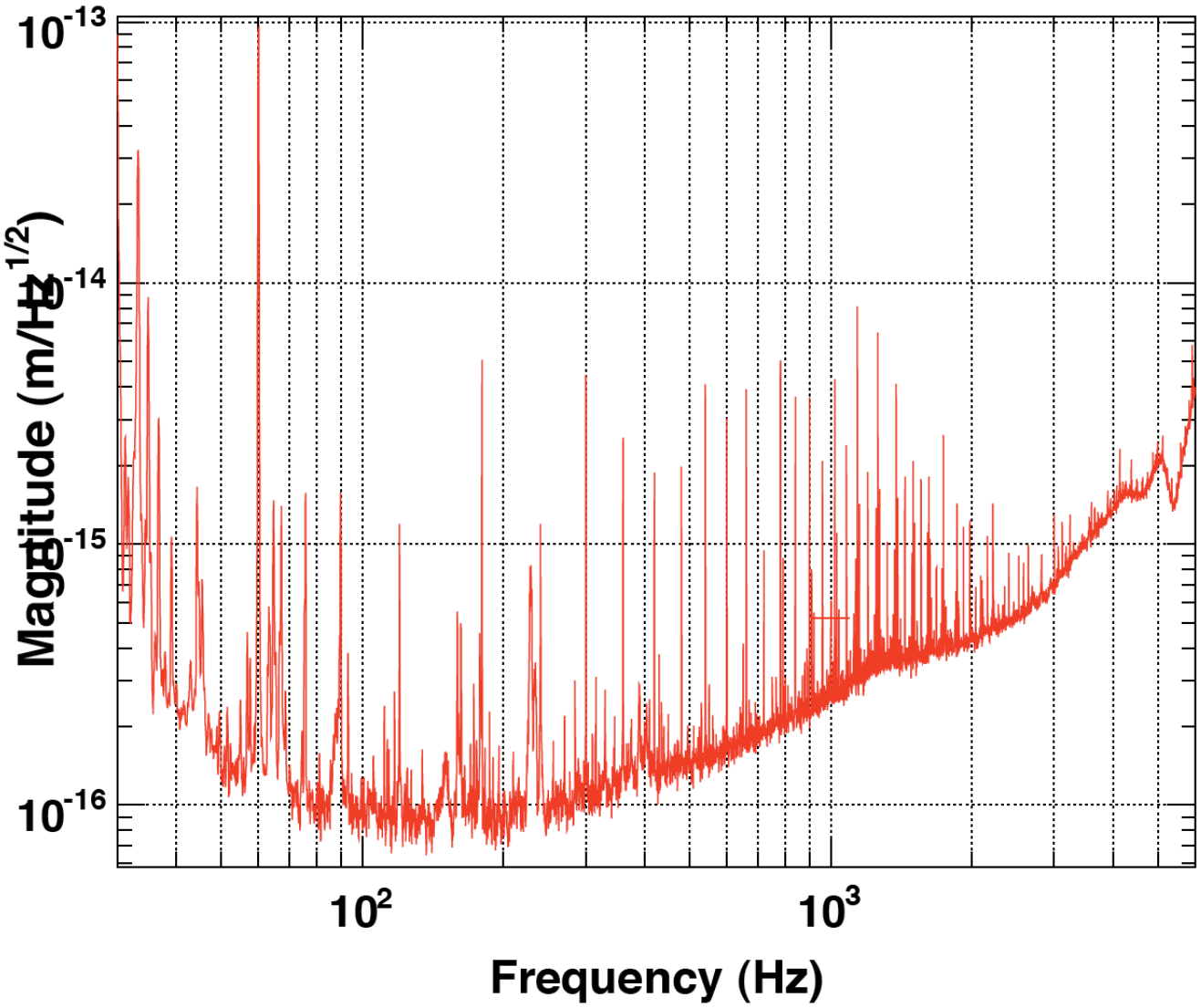

Anti Imaging filters
DAC adapter
Anti Alias filters
ADC adapter
Real time PC
CentOS 5.2+real time kernel
4core x 2 Xeon
PCIe接続
ADC/DAC
In Expansion Chassis
ADC:32ch/枚、$4K
DAC:16ch/枚、$3.5K
Binary Output:32ch/枚、$250
To NIM modules


Differential receiver
Differential driver
From DAC adapter
To ADC adapter

Arm locked using digital loop!



First noise curve with digital control



- 2 and half orders noisier than analog sensitivity
- Too much ADC/DAC noise
- Sensitivity will be improved once whitening / dewhitening filters are installed.

Development on digital

Developed systems at CLIO using digital system

- Auto initial alignment system for MC using picomotor
- Auto Lock acquisition system
- Calibration system
- Local damping system -> Takanori's talk this afternoon

Very near future

- The same sensitivity as analog with whitening/dewhitening filters
- Auto beam centering system (sensitivity depends on beam centering strongly at CLIO)
- Long term monitors for laser power, seismic motion, temperature etc.
- Auto noise budget system