Status of Japanese Projects

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Introduction

LCGT

Large Cryogenic Gravitational wave Telescope

future plan for 3-km interferometer
in an underground mine with cryogenic mirrors

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Large Cryogenic Gravitational wave Telescope

future plan for 3-km interferometer
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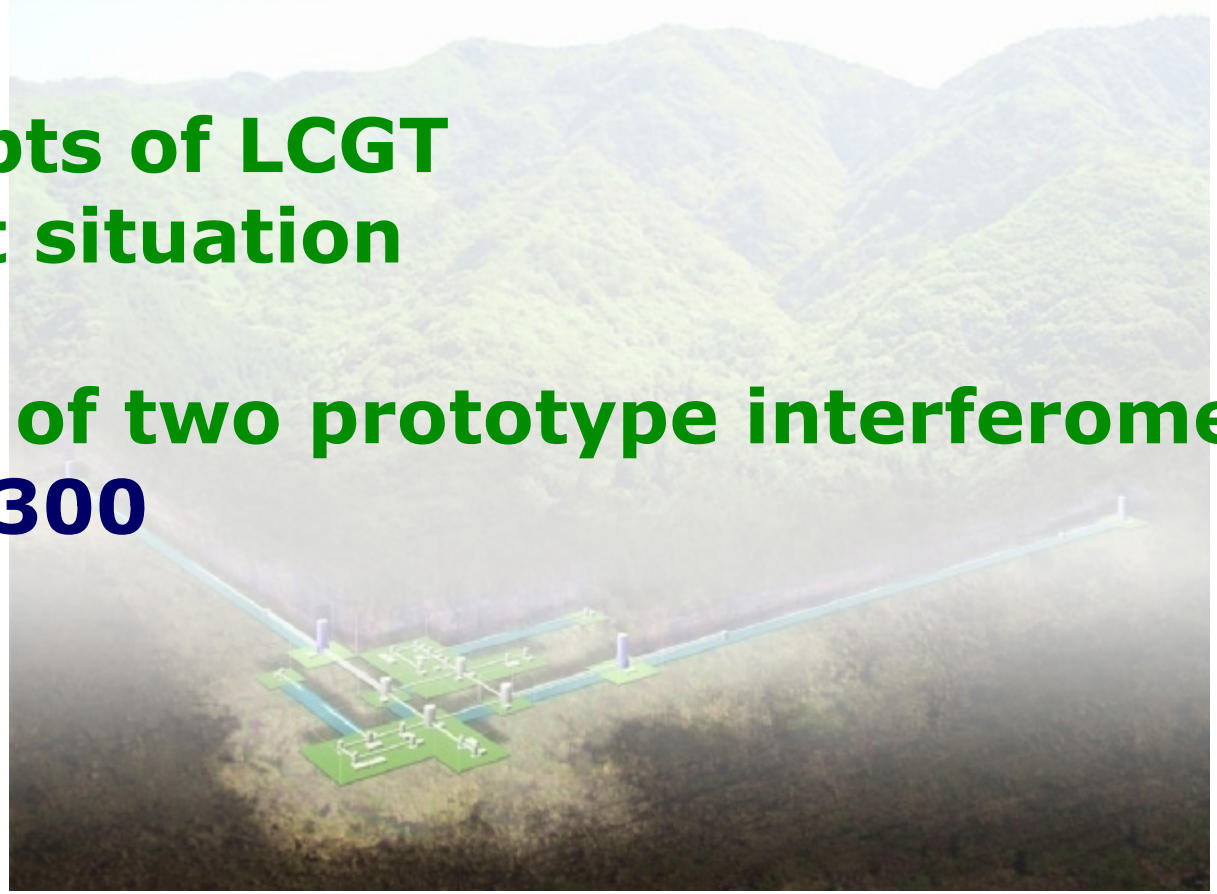
Overview

- Concepts of LCGT
- Recent situation

- Status of two prototype interferometers
  TAMA300
  CLIO



Concepts of LCGT

Three key features

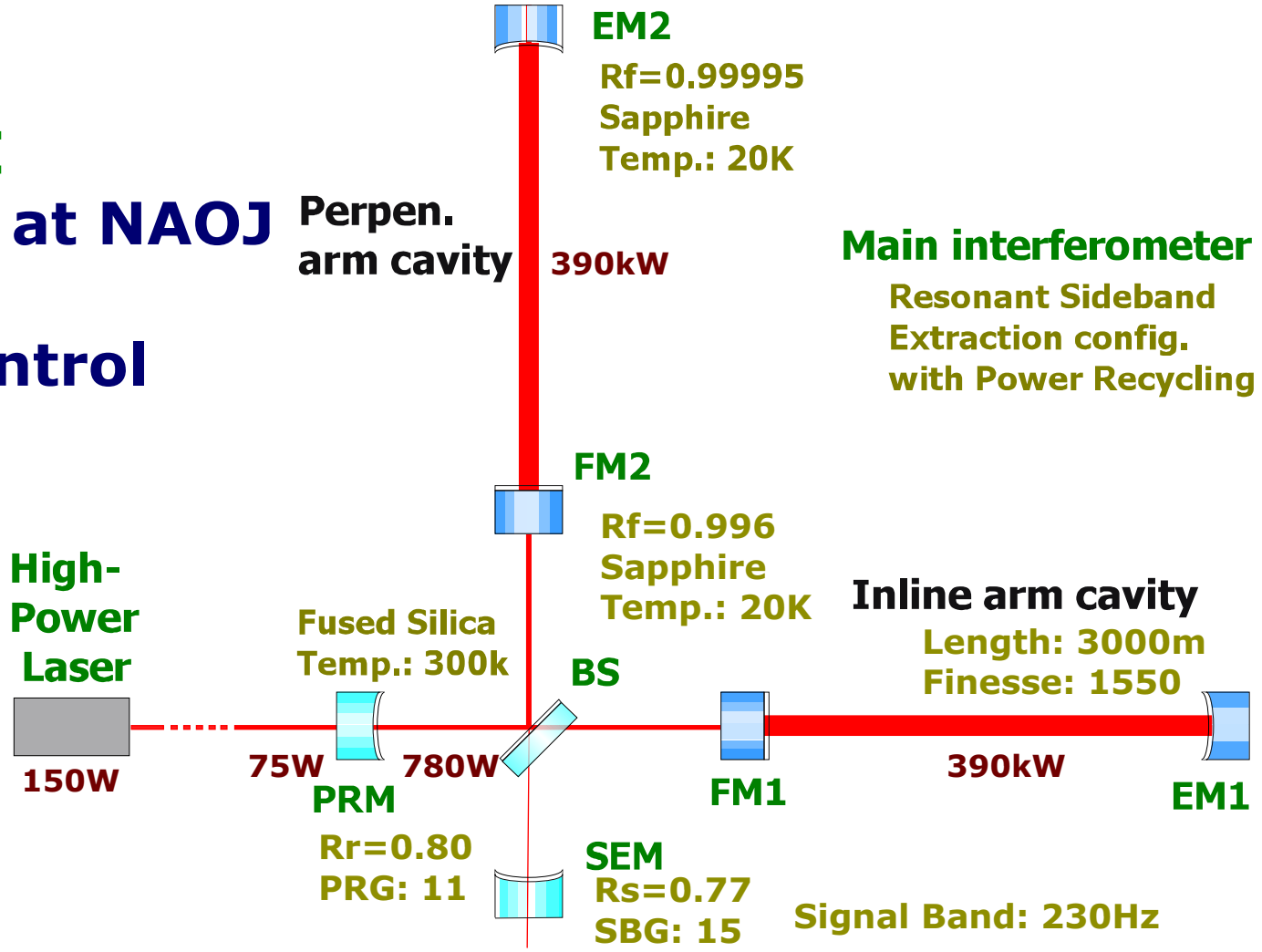
- 3-km interferometer
- Underground site
- Cryogenic sapphire test masses

Feature 1: 3-km IFO

3-km dual recycled interferometer

- **We have made steady step-ups since '90s**
  3m, 20m, 100m, and 300m
  => km-class IFO

- **Experiences on RSE**
  - 4m prototype tests at NAOJ
  - Test of optical conf.
  Sensing & Control
  => TAMA300



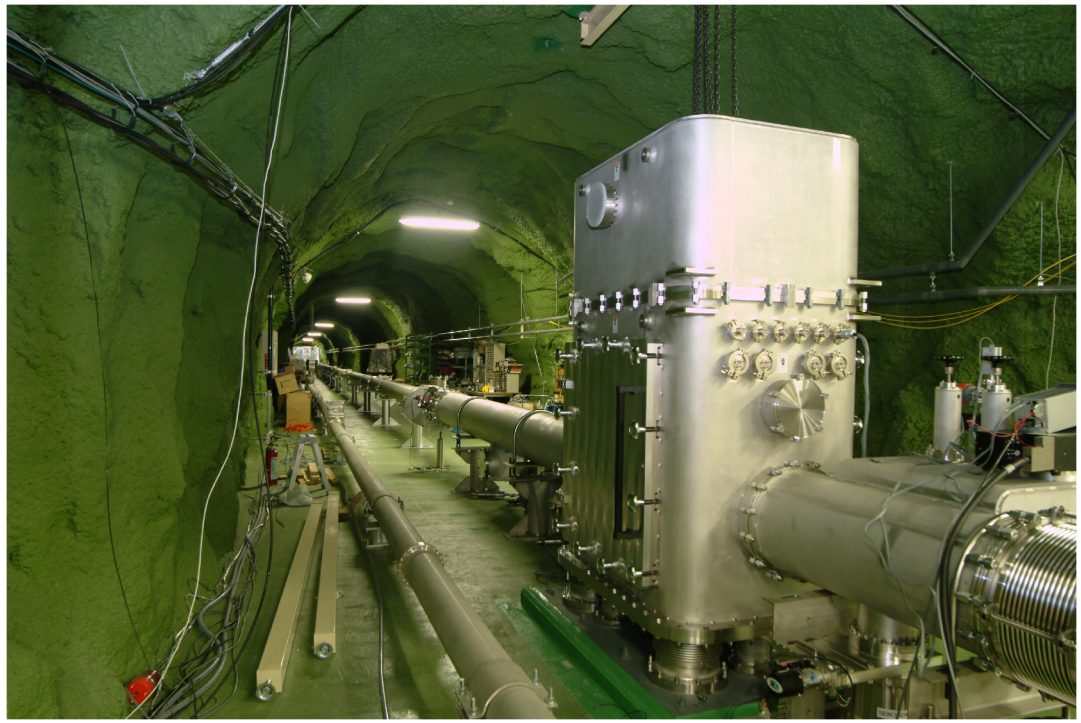
Feature 2: Underground site

Kamioka mine

- **Seismic activity:**
  100~1000 times quieter than that of the TAMA site
  => direct merit of small seismic motion
  => indirect advantages
  e.g. upconversion noise, stationarity of the sensitivity

- **Facilities:**
  in-mine administratations
  offices / dormitories
  => Well maintained
  for scientific activities

  i.e. Super Kamiokande /
  KamLand / XMASS



Feature 3: Cryogenic mirrors

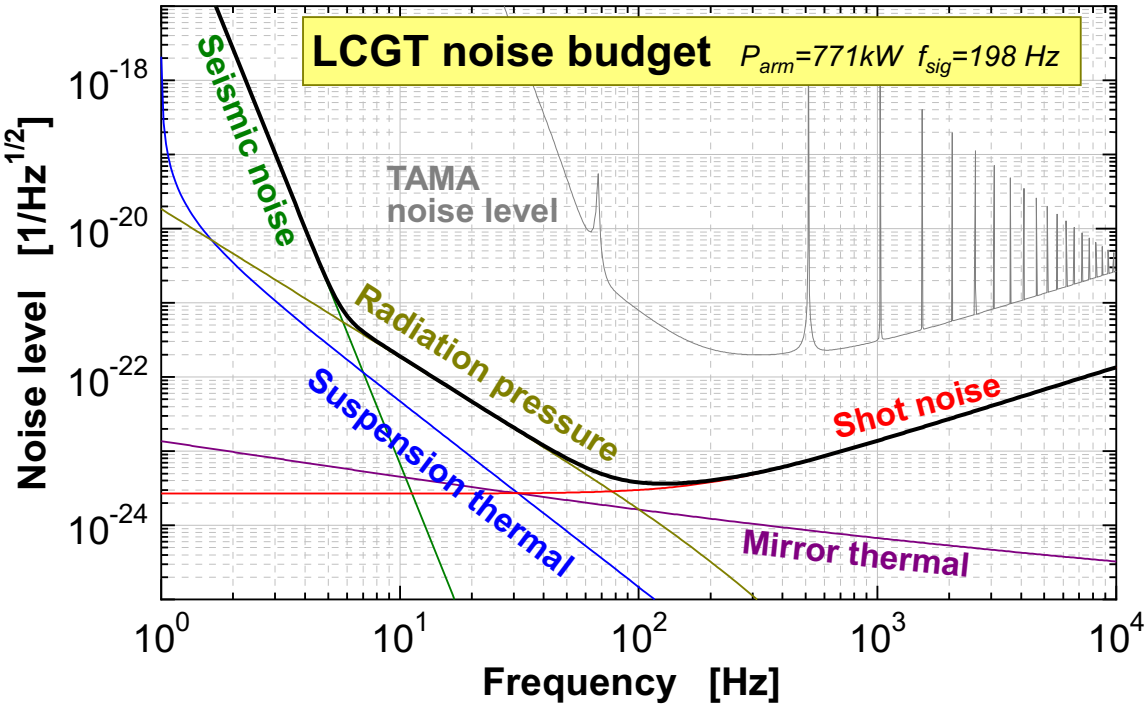
Use of sapphire mirrors at 20K

Benefit of mirror cooling

- Reduction of thermal noise
  mirror / suspension / coating / thermoelastic
- Better thermal conduction
  suppression of
  thermal lensing

Technical challenges

- Low-vibration cryogenics
- Sapphire wire suspension
- Low absorption
  in the mirrors/coatings



Cryogenic prototype => CLIO

Some news from LCGT

- ***New project manager***

LCGT invited Prof. I. Nakatani as a PM, formerly worked at JAXA (Japanese space agency) for many space missions

=> Enhancement of the management / the system engineering

=> Reorganizaton of TAMA/CLIO activities among the LCGT R&D

- ***Buget requesting ~ submitted for 2010***

The request went out from Univ. of Tokyo to MEXT

(Ministry of Education, ...)

- ***Progress of the prototype development***

TAMA improved the sensitivity with SAS

=> Effort shifted to the new optical configuration

CLIO reached to the thermal noise limit at room temp.

=> Proceed to the noise hunting at cryogenic temp.

TAMA300

300-m interferometer

- Located at Mitaka near Tokyo
- 300-m FP arms
- FP Michelson
  with power recycling

Current target of TAMA300

- Development of TAMA-SAS

- Establishment of interferometer technologies for LCGT
  => Interferometer configuration / sensing and control

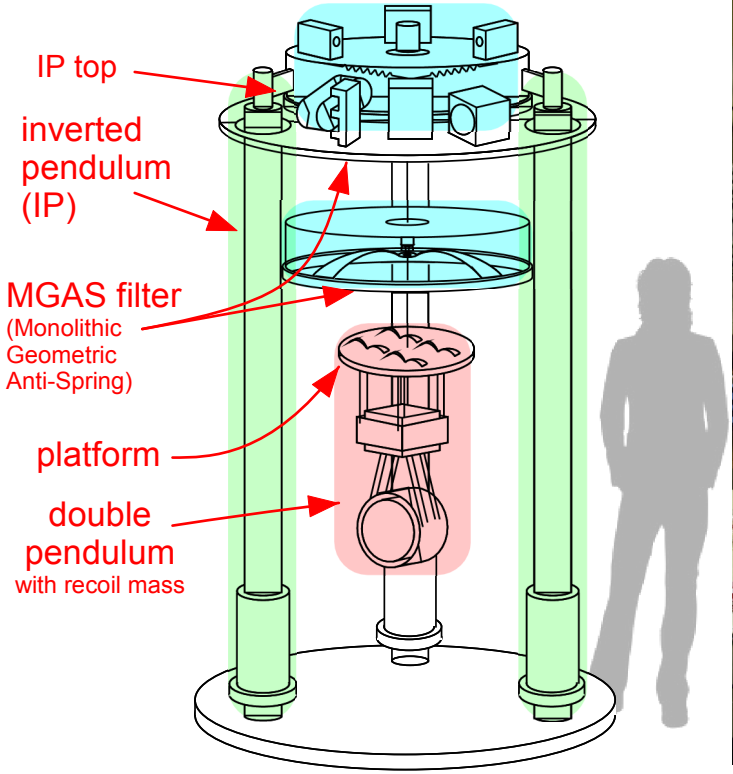
TAMA-SAS

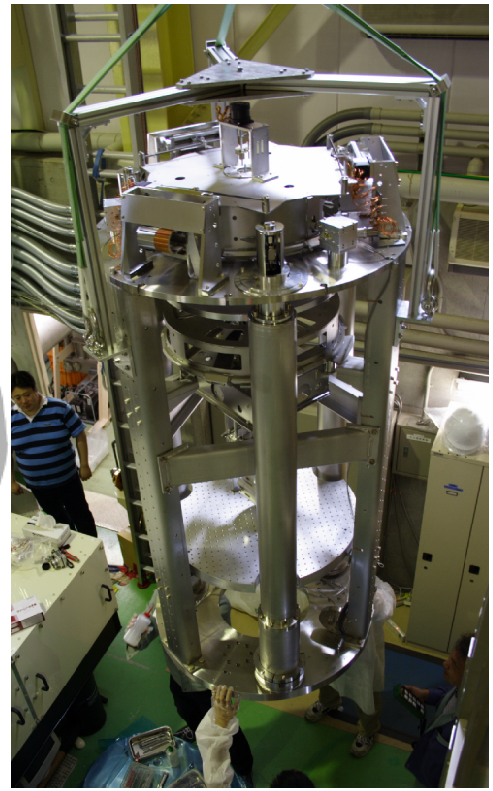
Interferometer operation with TAMA-SAS

- **TAMA-SAS: low frequency vibration isolation system developped by the international collaboration of LIGO Caltech / Univ. of Pisa / TAMA**

- **Passive vibration isolation**
  Inverted pendulum
  Vertical filters (MGAS)
  Double pendulum

- **Active damping**





TAMA Sensitivity

Low freq motion

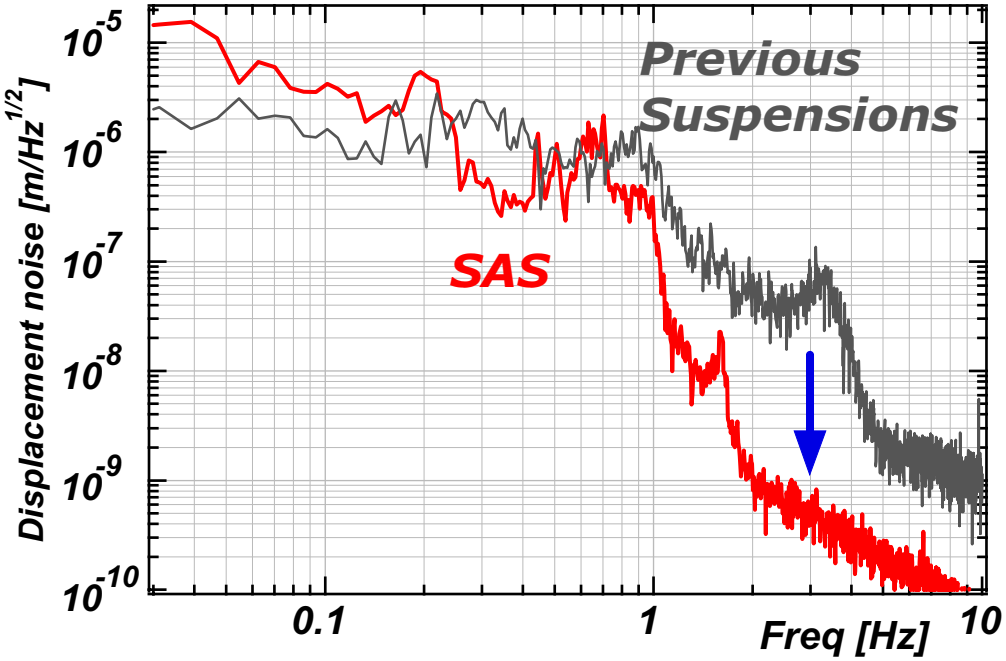
- Improvement above 0.2Hz

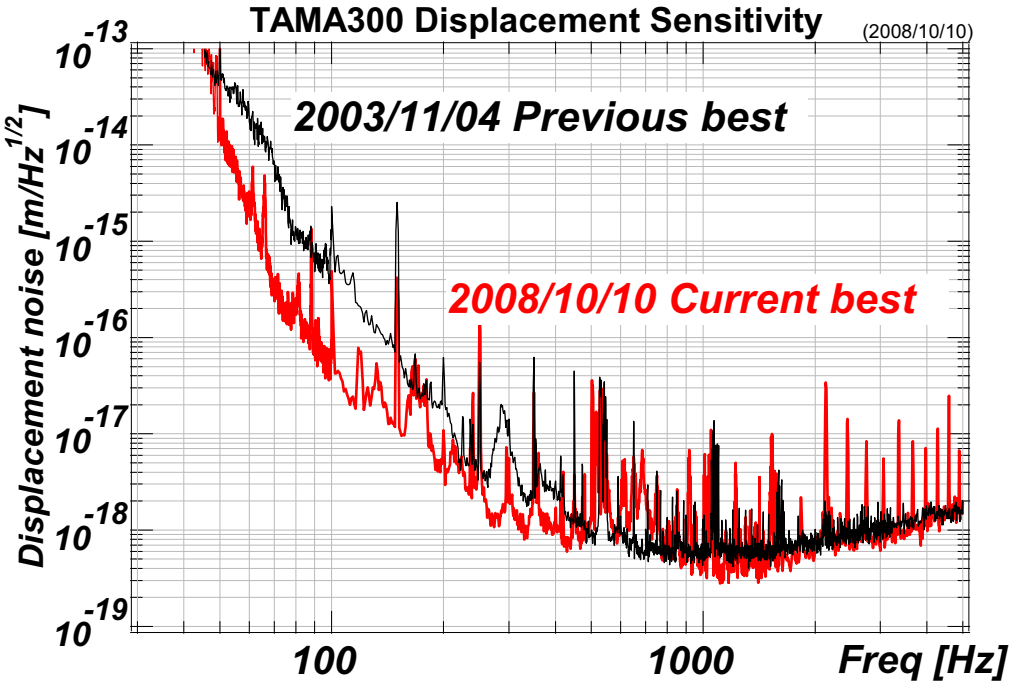
Observation band

- Sensitivity improvement

  => 4×10^{-19} m/rtHz @1kHz

Achieved reduction of alignment control noise with TAMA-SAS





TAMA expresses our gratitude to
the SAS team of LIGO Caltech & Univ of Pisa.

We also thank Dr. Grote
for the WFS work during his stay at TAMA.

Toward TAMA-RSE

- ***TAMA RSE***

Test for the LCGT optical configuration

- Integration of the past prototype tests at NAOJ

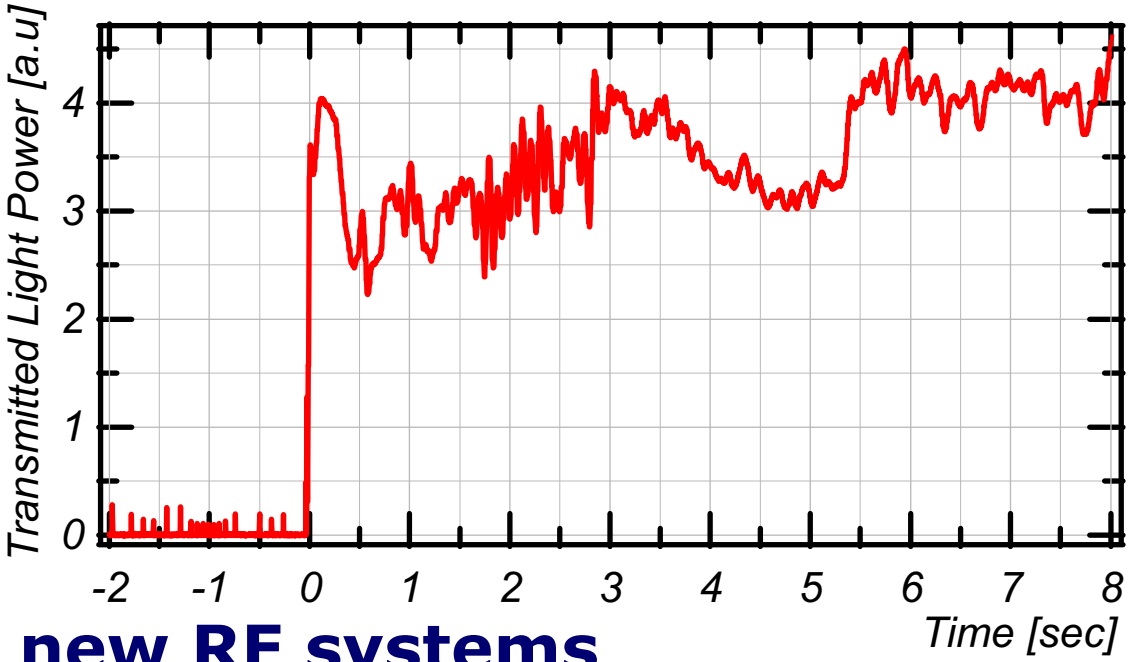
Preparation Status

- Length control design ***done***

- Alignment control design ***in progress***

- PRM replacement (Jan-2009)

- Lock achieved with new PRM (Feb-2009)



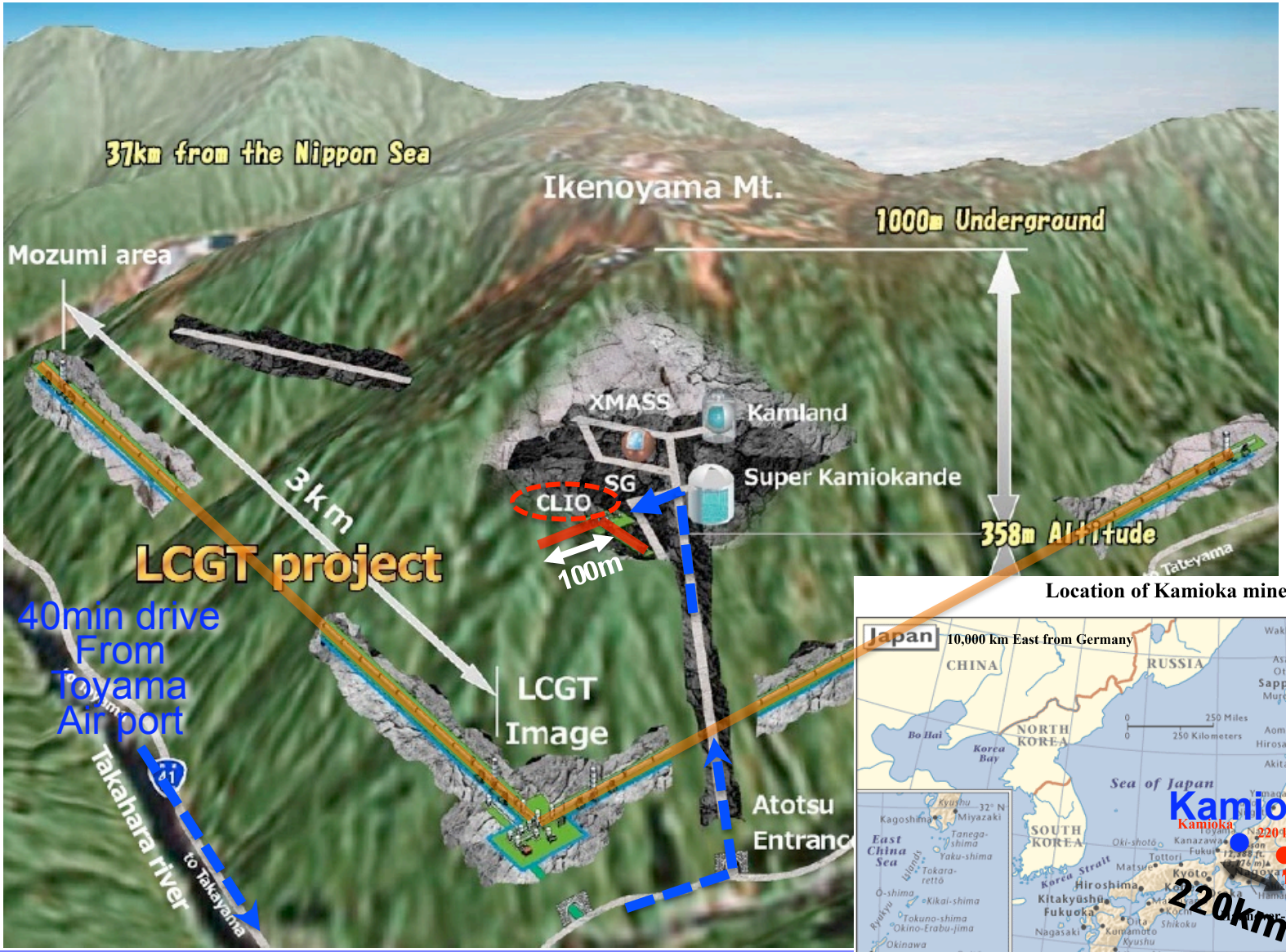
- 2009: Constructions of the new RF systems

- 2010: Placement of SEM => RSE lock trial

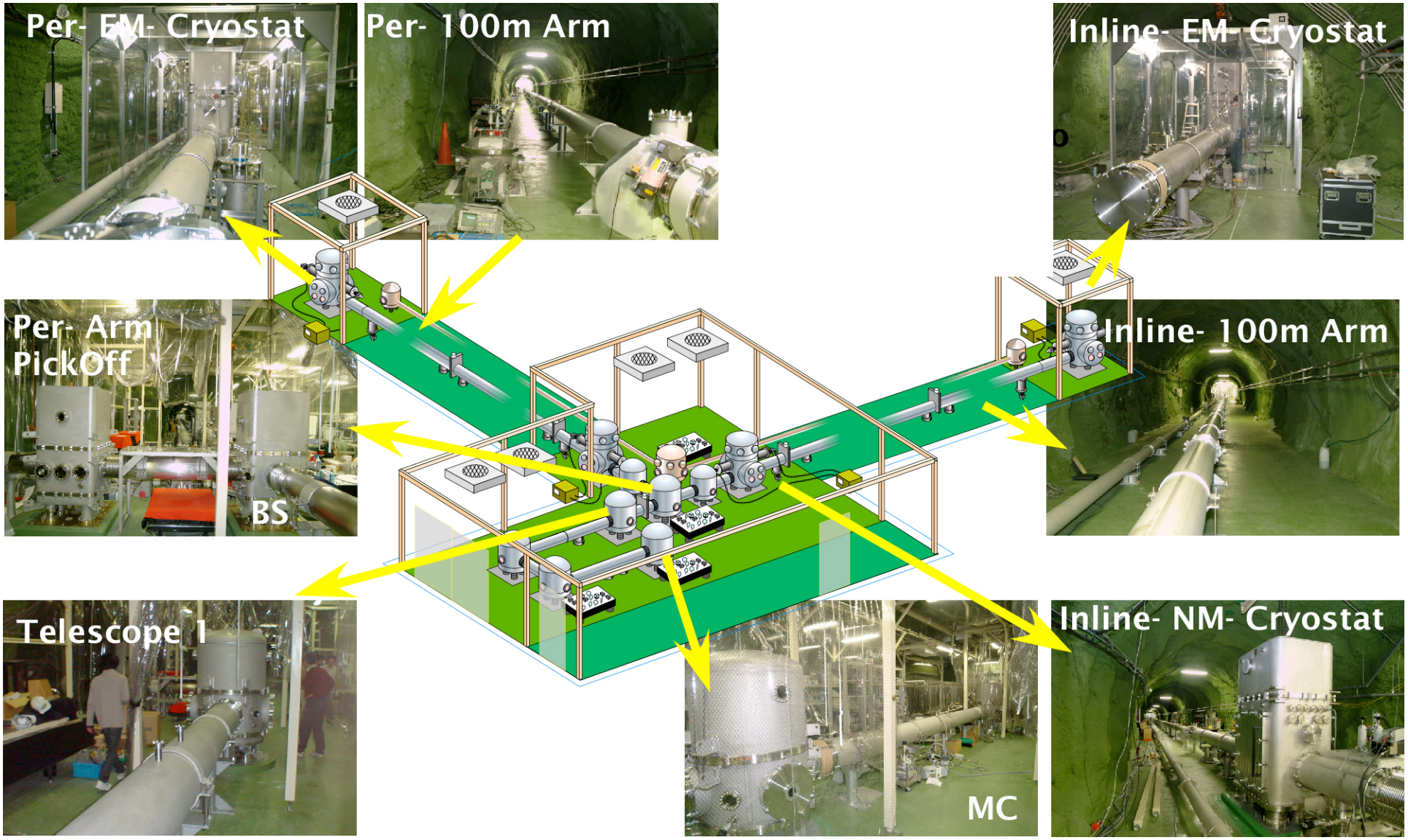
CLIO 100m prototype underground

- 100 meter scale, cryogenic interferometer
- Underground in Kamioka mine, very quiet seismic environment
- Locked-FP type (Caltech old 40meter Mark II style)
- 2W laser, 9.5m MC, Suspensions designed for cooling
- Prototype for LCGT, km scale project of Japan
- Reached to suspension/mirror thermal noise in room temperature
- Ready to cool down soon!

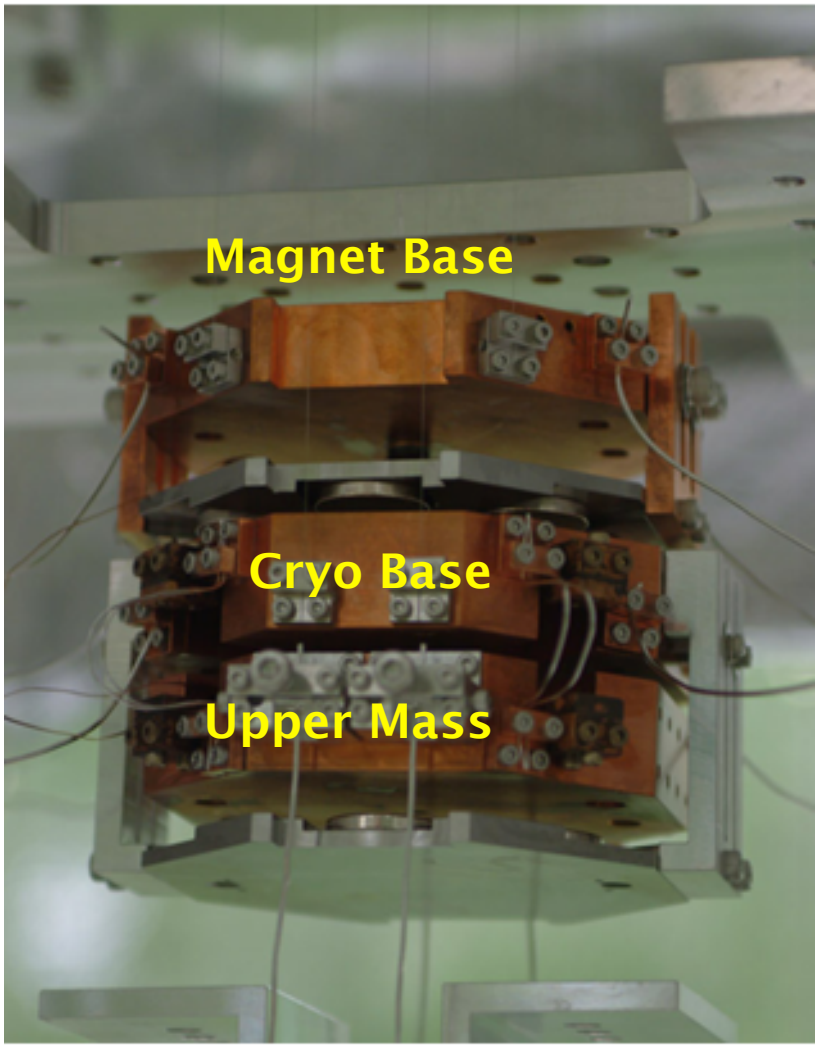
Laboratories underground, in Kamioka mine

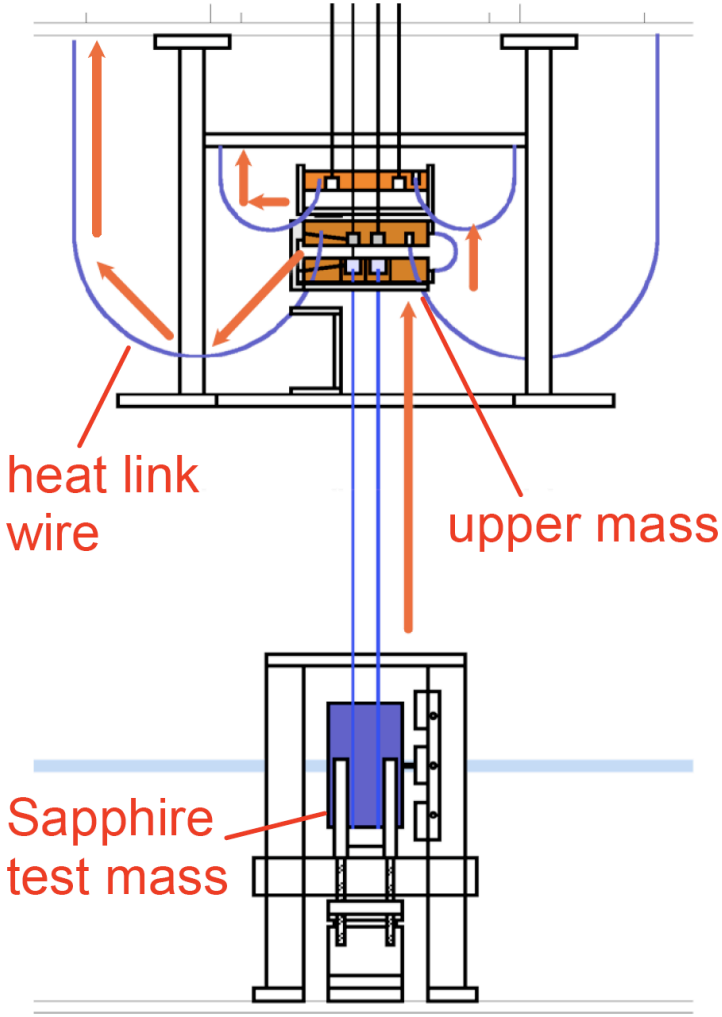


CLIO in Kamioka mine



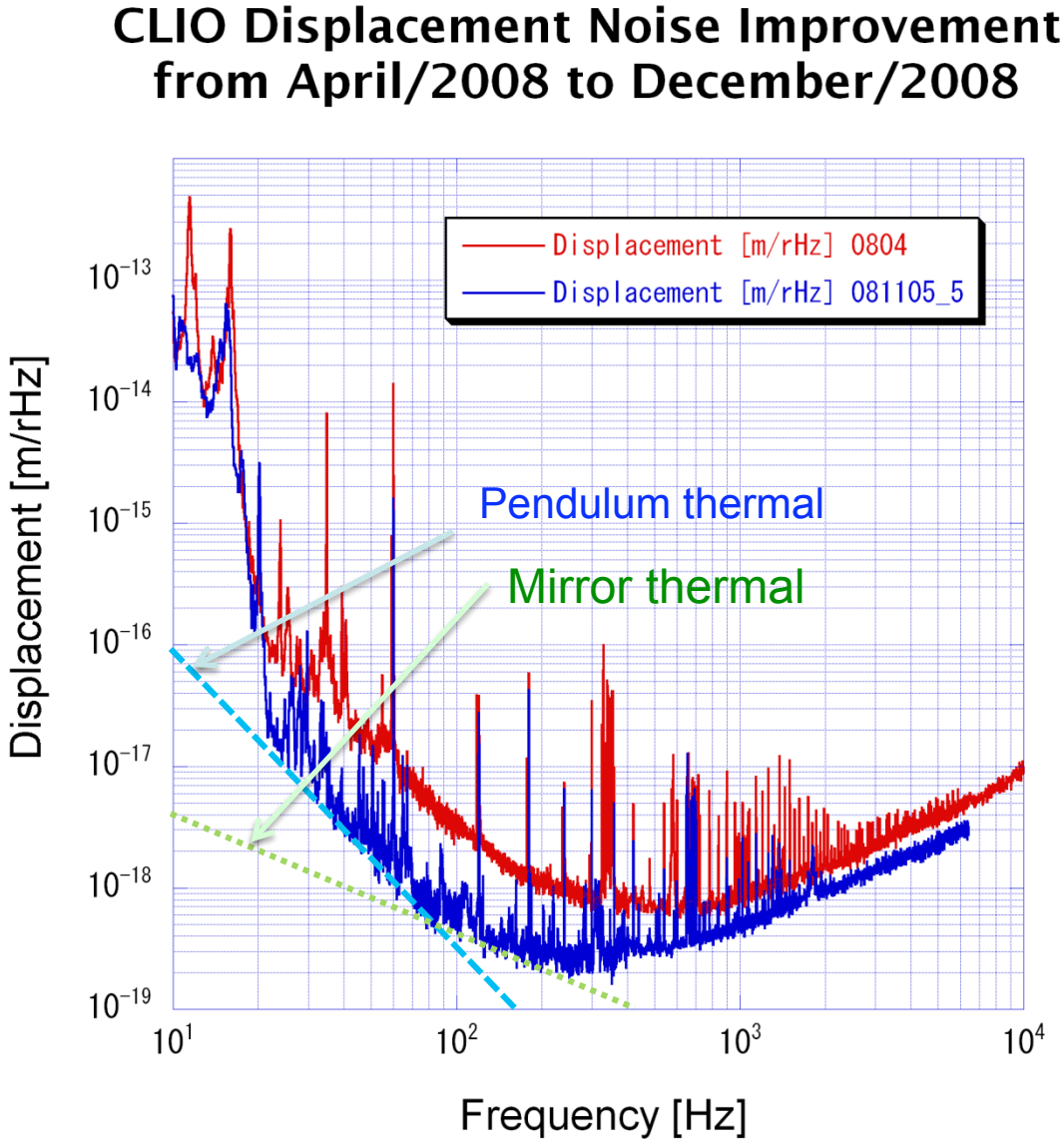
CLIO seismic attenuation for cooling

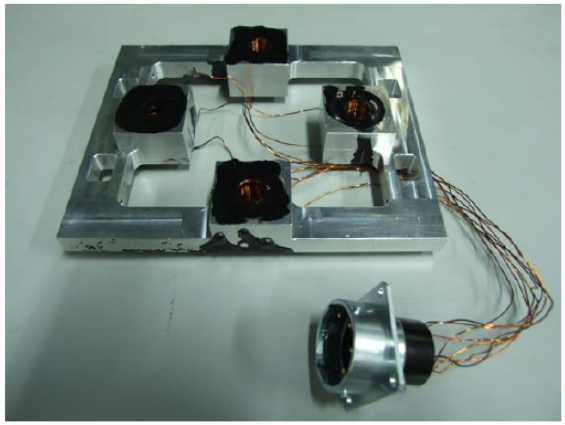




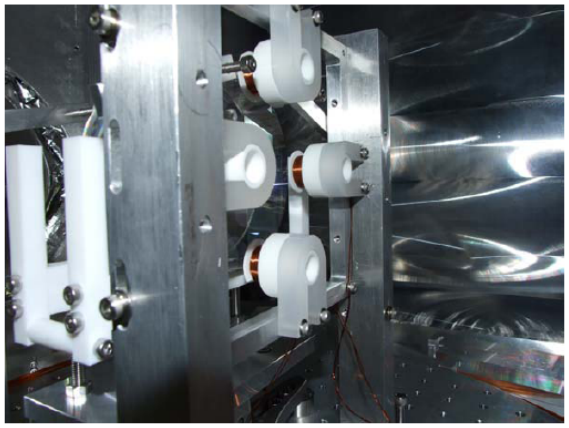
We cooled down all CLIO in 2007 and established full lock, but with not so good sensitivity. Then we moved back to room temperature again in 2008.

CLIO reached to thermal noise in the room temperature



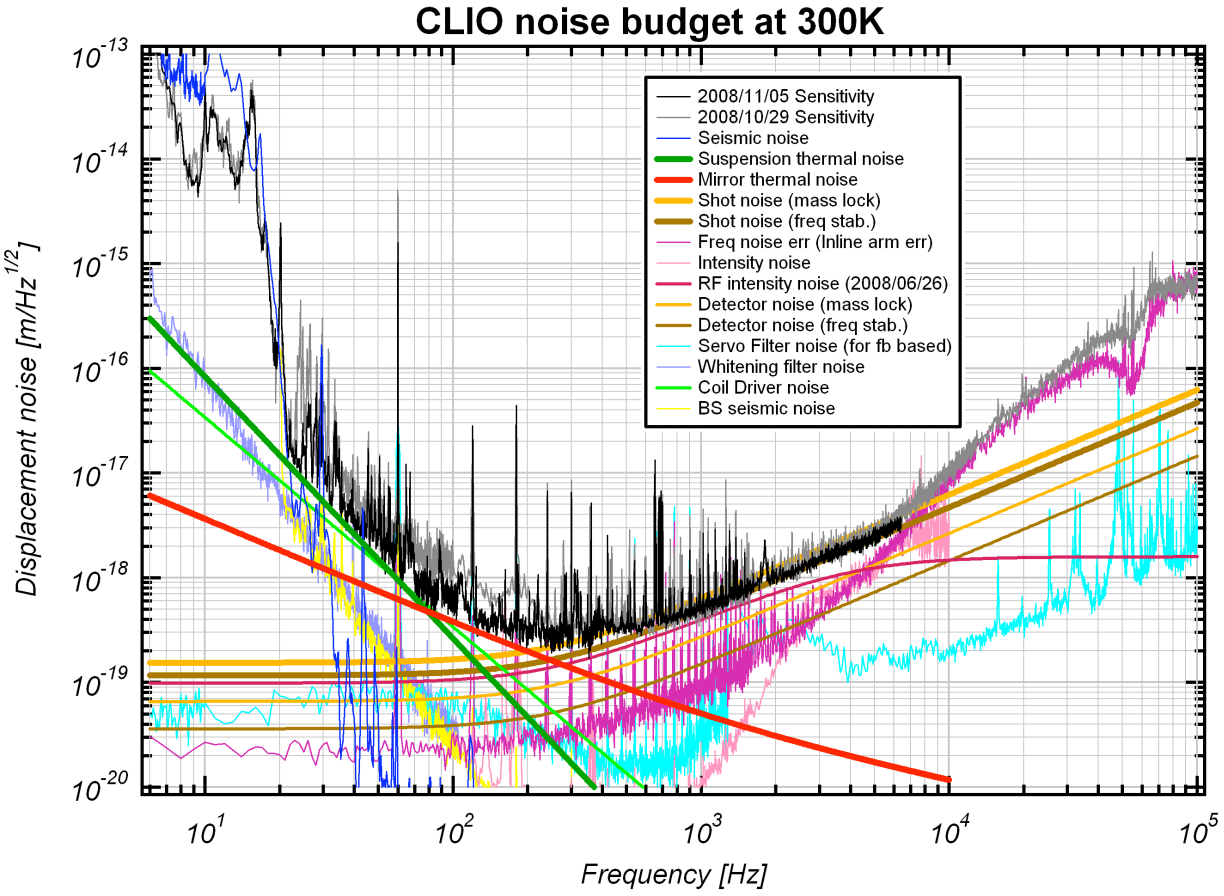


Problem: Eddy current in aluminum coil holders induced by magnets attached on mirror added mechanical loss on pendulum thermal noise



Solution: Aluminum holders were exchanged to ceramic and daifron holders.

Noise budget



Seismic noise limited in low frequency, Thermal in middle, Shotnoise in high.

We are preparing for *cooling* to observe improved thermal noise within a year.

Summary

LCGT **3km cryogenic interferometer at Kamioka mine**

- **Invited a new PM for project enhancement**
- **FY2010 budget requested**

TAMA **300m prototype GW detector**

- **Achieved sensitivity improvement with SAS**
- **RSE preparation in progress**

CLIO **100m cryogenic GW detector at Kamioka mine**

- **Aiming demonstration of noise reduction by cooling**
- **Test for the data quality at the underground site**
- **Demonstrated the thermal noise level at room temp.**
- **Noise hunting with cryogenic operation in preparation**

Noise

- ***Estimation of the noise contribution for TAMA300***

Angular control noise reduced

=>Owing to the reduced angular motion of the test mass in the 1Hz-10Hz band

=> Low freq. excitation experiment revealed upconversion noise limits the sensitivity at 100~500Hz