Status of Japanese Projects

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Introduction

LCGT

Large Cryogenic Gravitational wave Telescope

3-km interferometer in an underground mine with cryogenic test masses

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Large Cryogenic Gravitational wave Telescope

3-km interferometer in an underground mine with cryogenic test masses

Overview

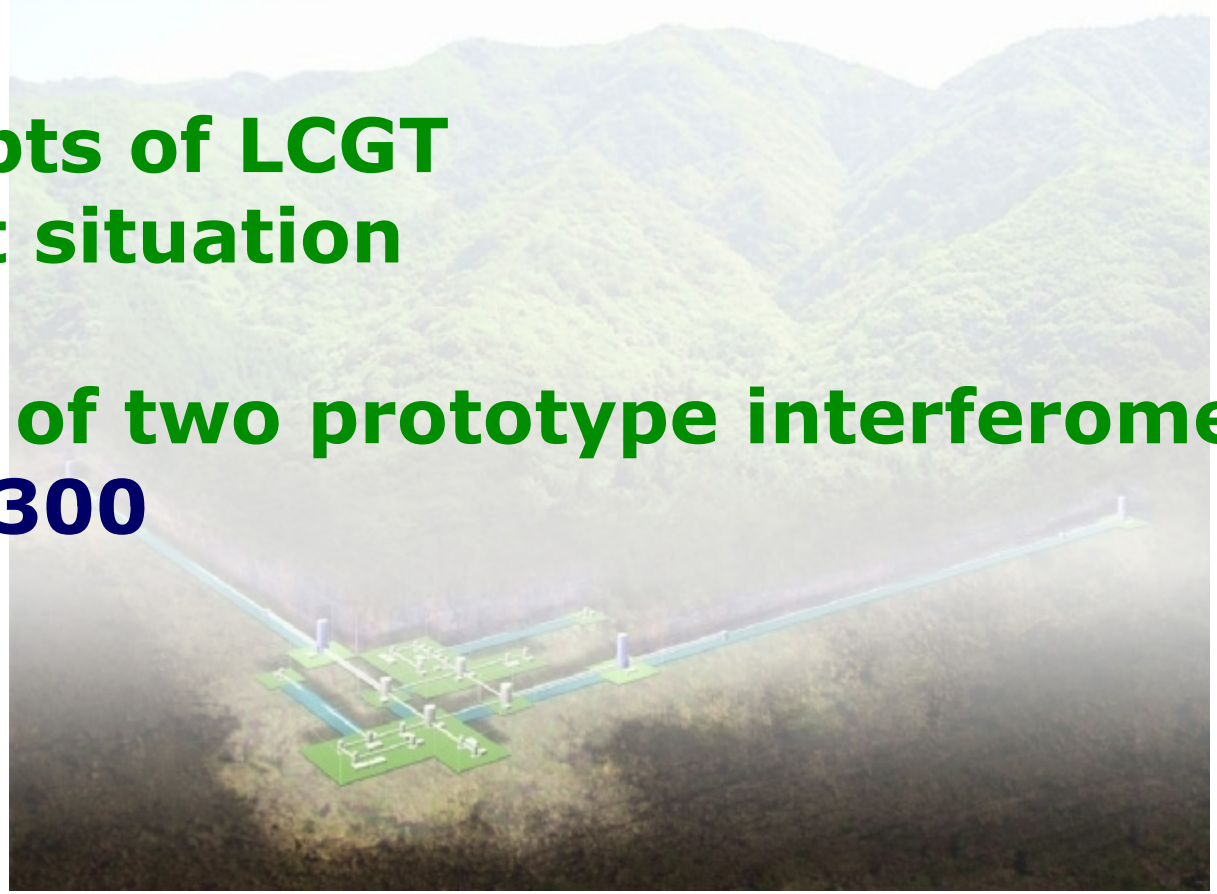
- Concepts of LCGT

- Recent situation

- Status of two prototype interferometers

TAMA300

CLIO



Concepts of LCGT

Three key features

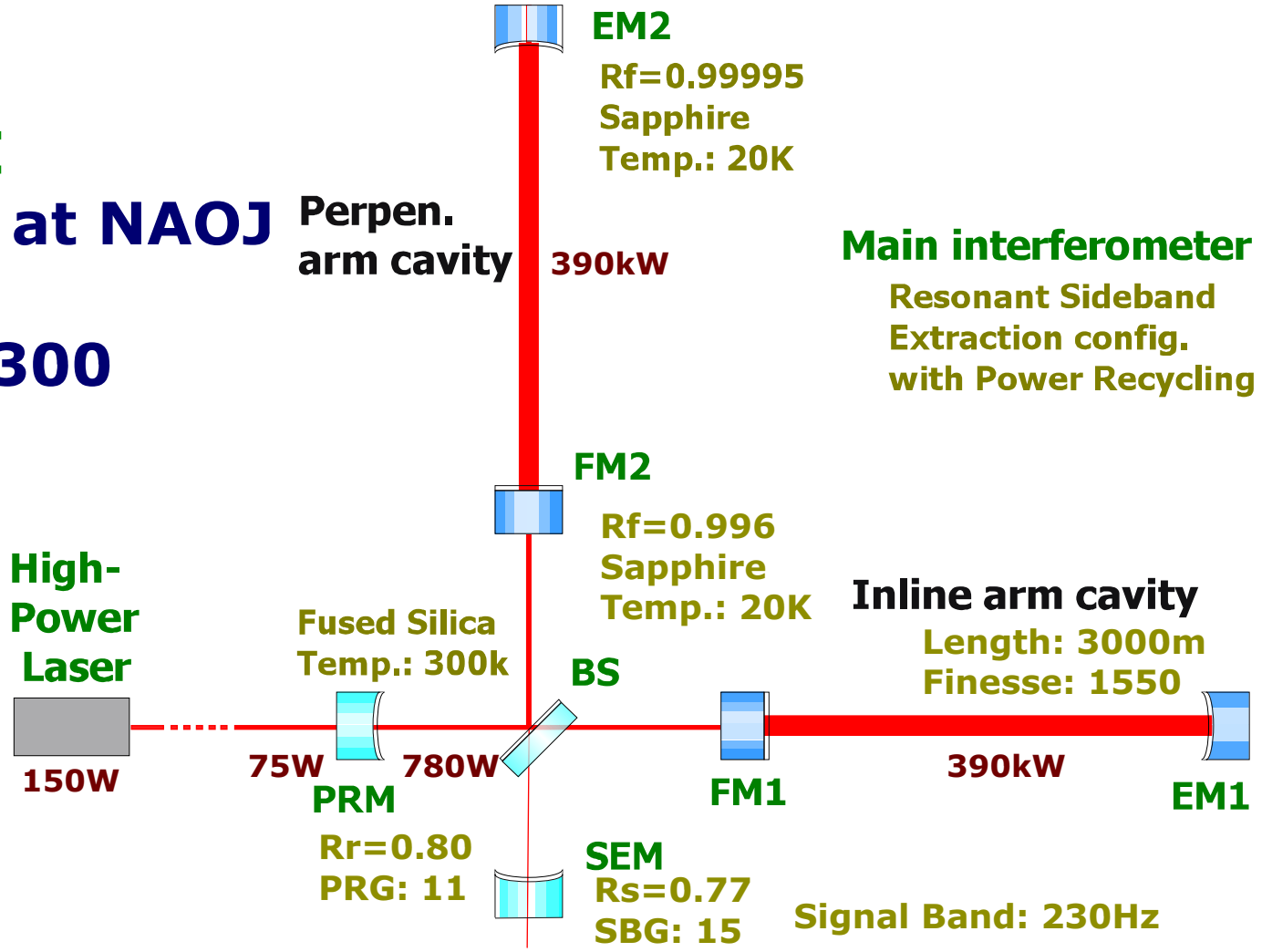
- 3-km interferometer
- Underground site
- Cryogenic sapphire test masses

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
  - now working
    on RSE of 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

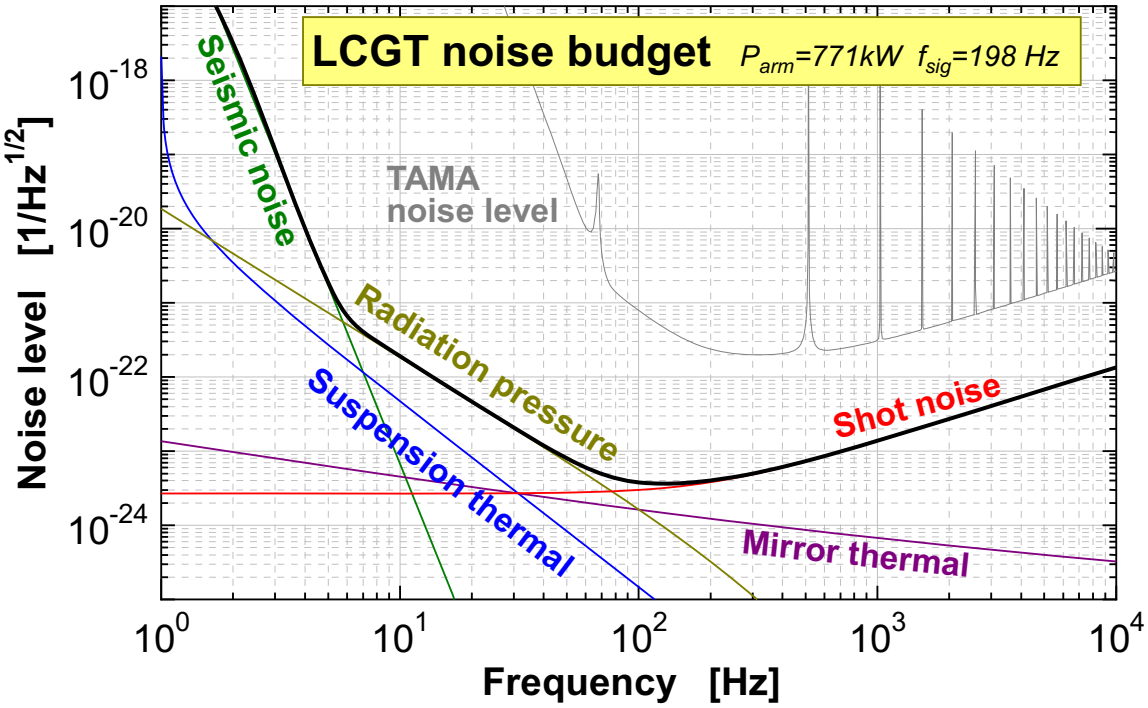
Use of sapphire mirrors at 20K

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 thermal absorption
  in the mirrors/coatings



Cryogenic interferometer => 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

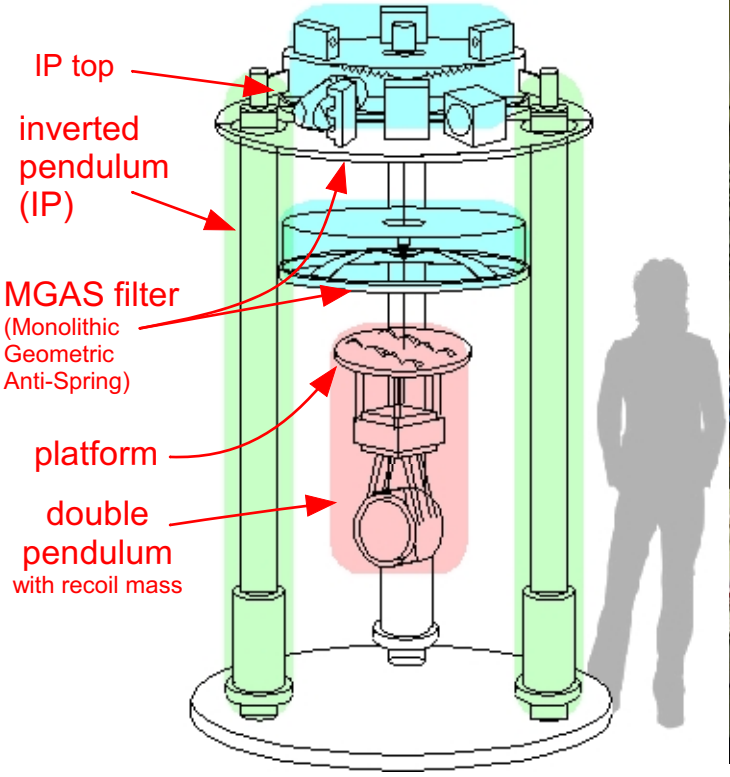
TAMA-SAS

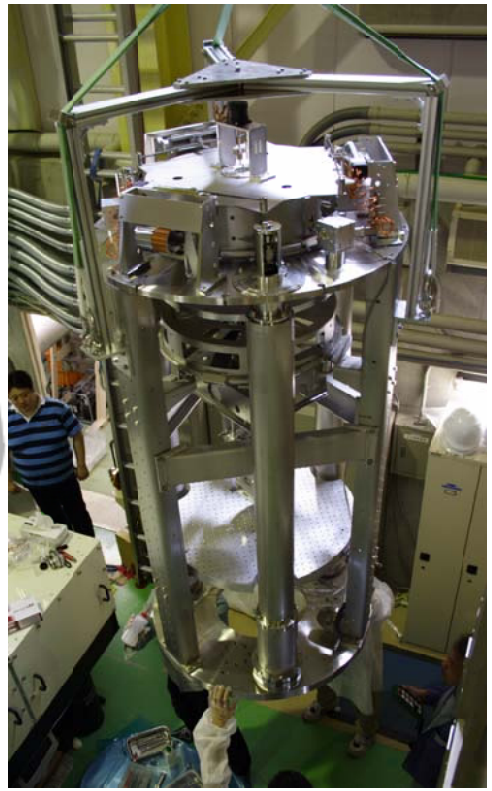
Interferometer operation with TAMA-SAS

- **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

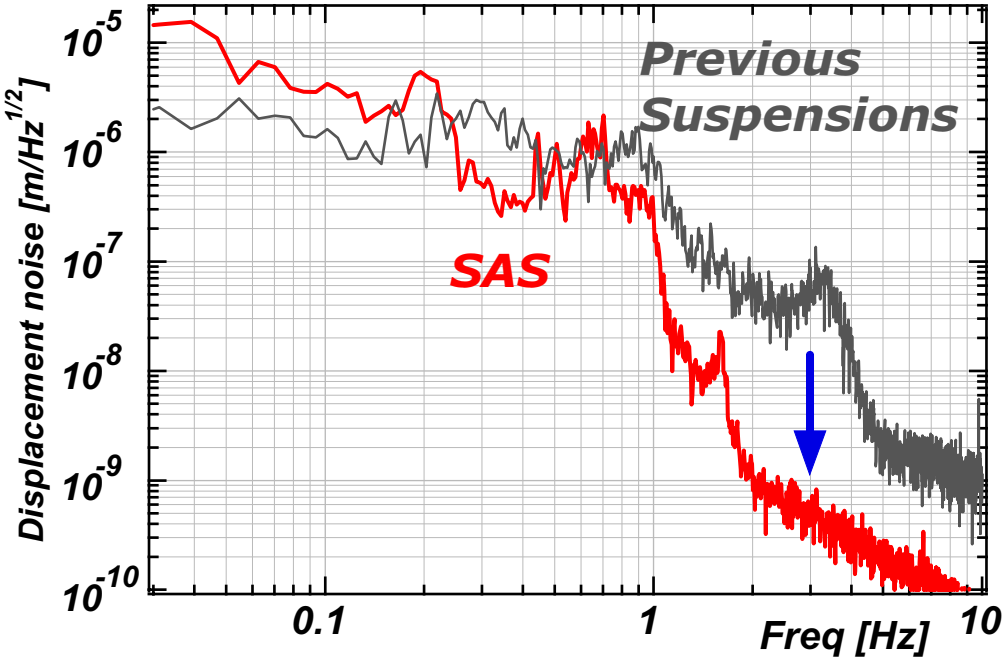
- Improvement above 0.2Hz

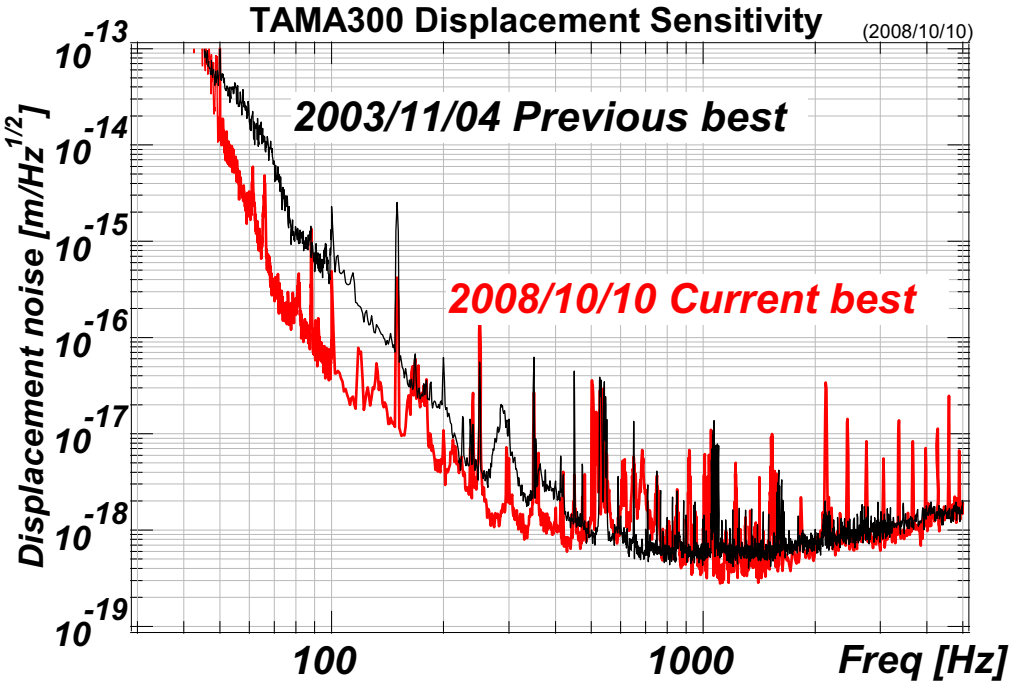
Observation band

- 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

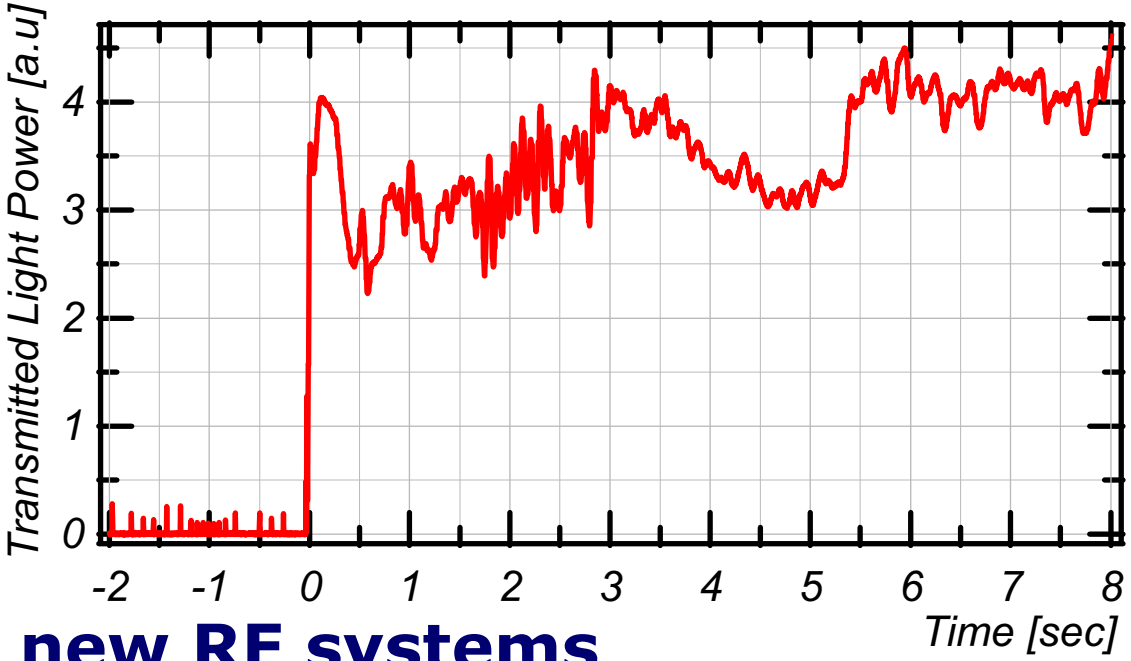
Preparation Status

- Length control design ***done***

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

- PRC mirror replacement (Jan-2009)

- Lock achieved with the new PRC (Feb-2009)



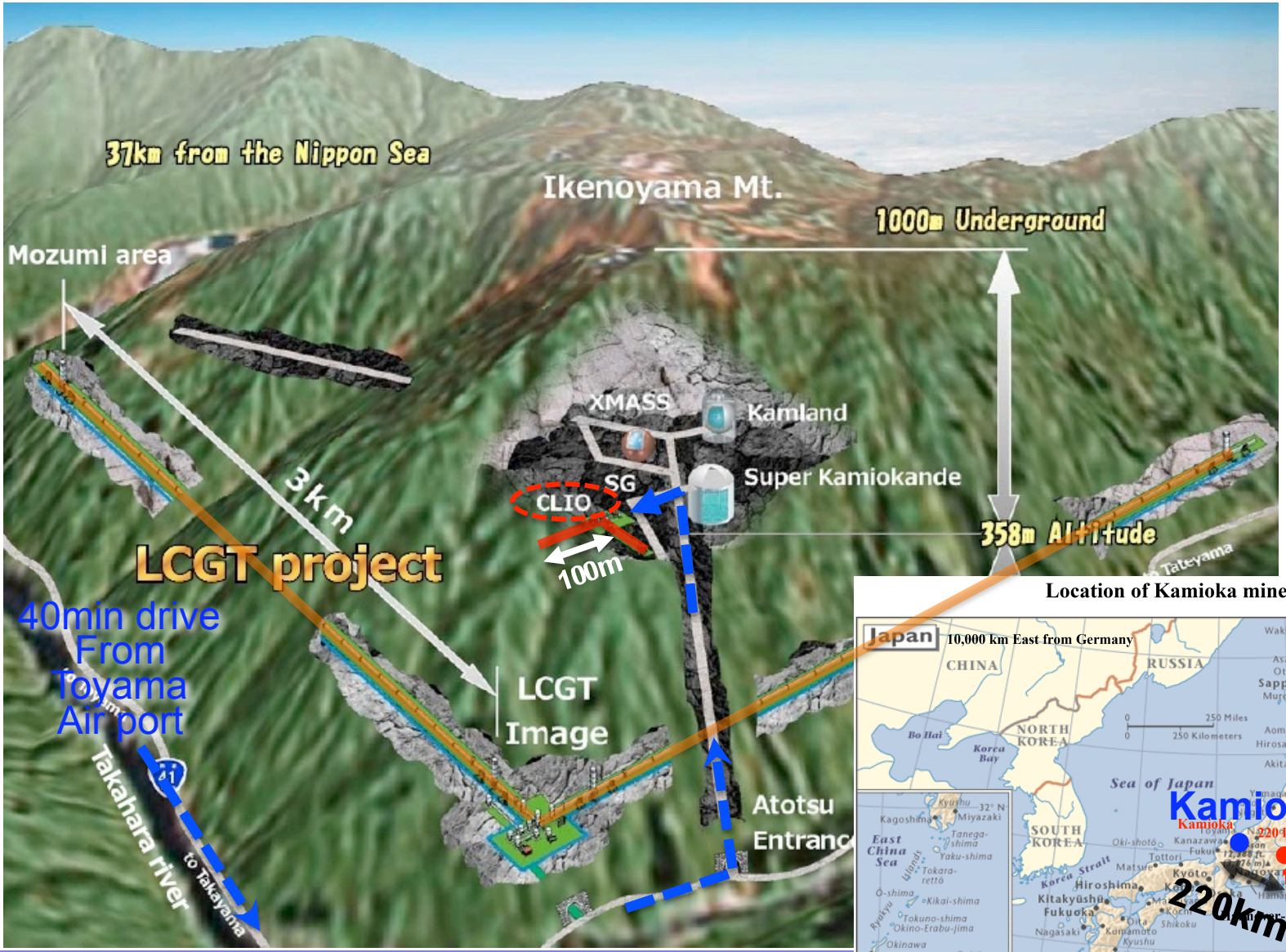
- 2009: Constructions of the new RF systems

- 2010: Placement of SEM => RSE lock trial

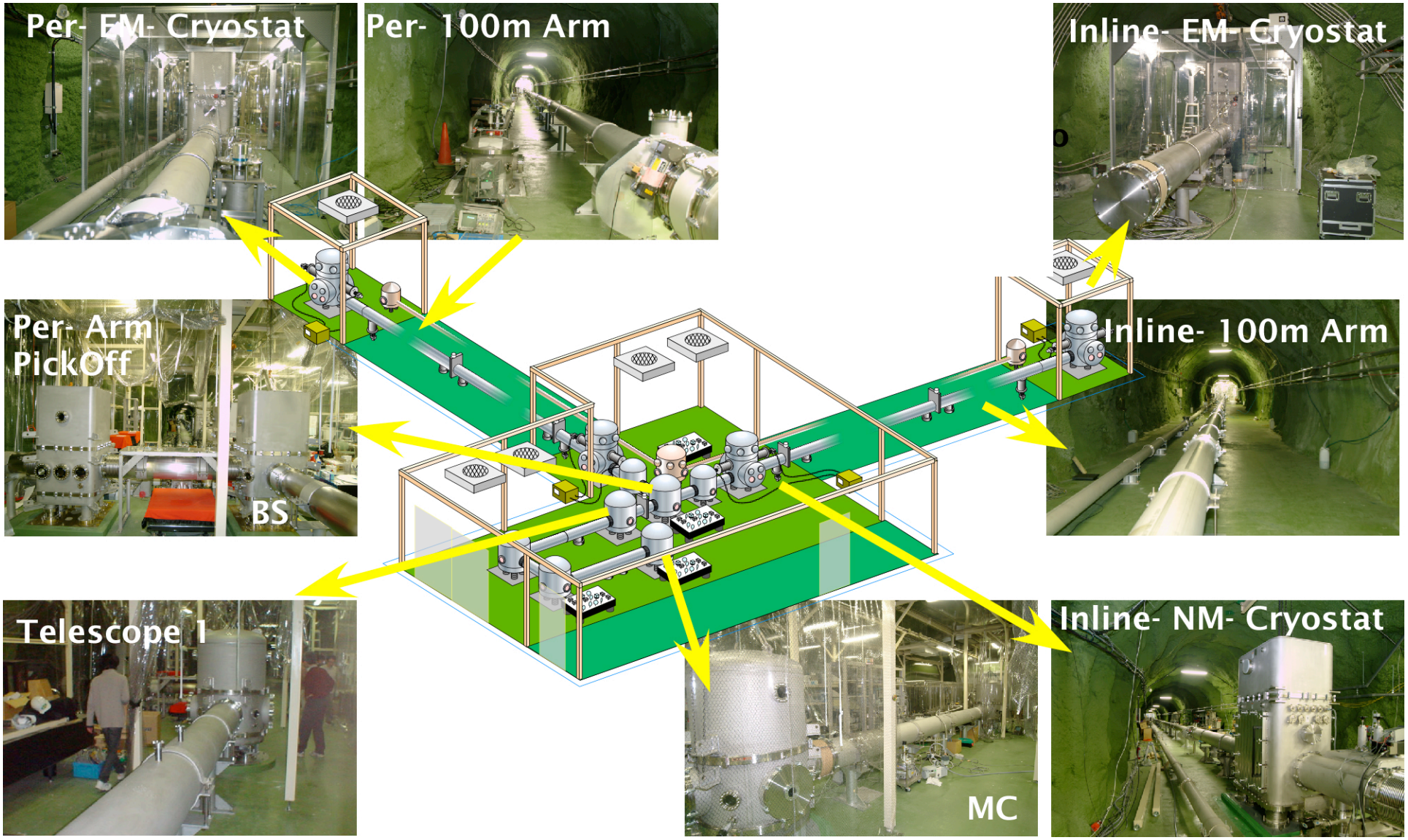
CLIO 100m prototype underground

- 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!

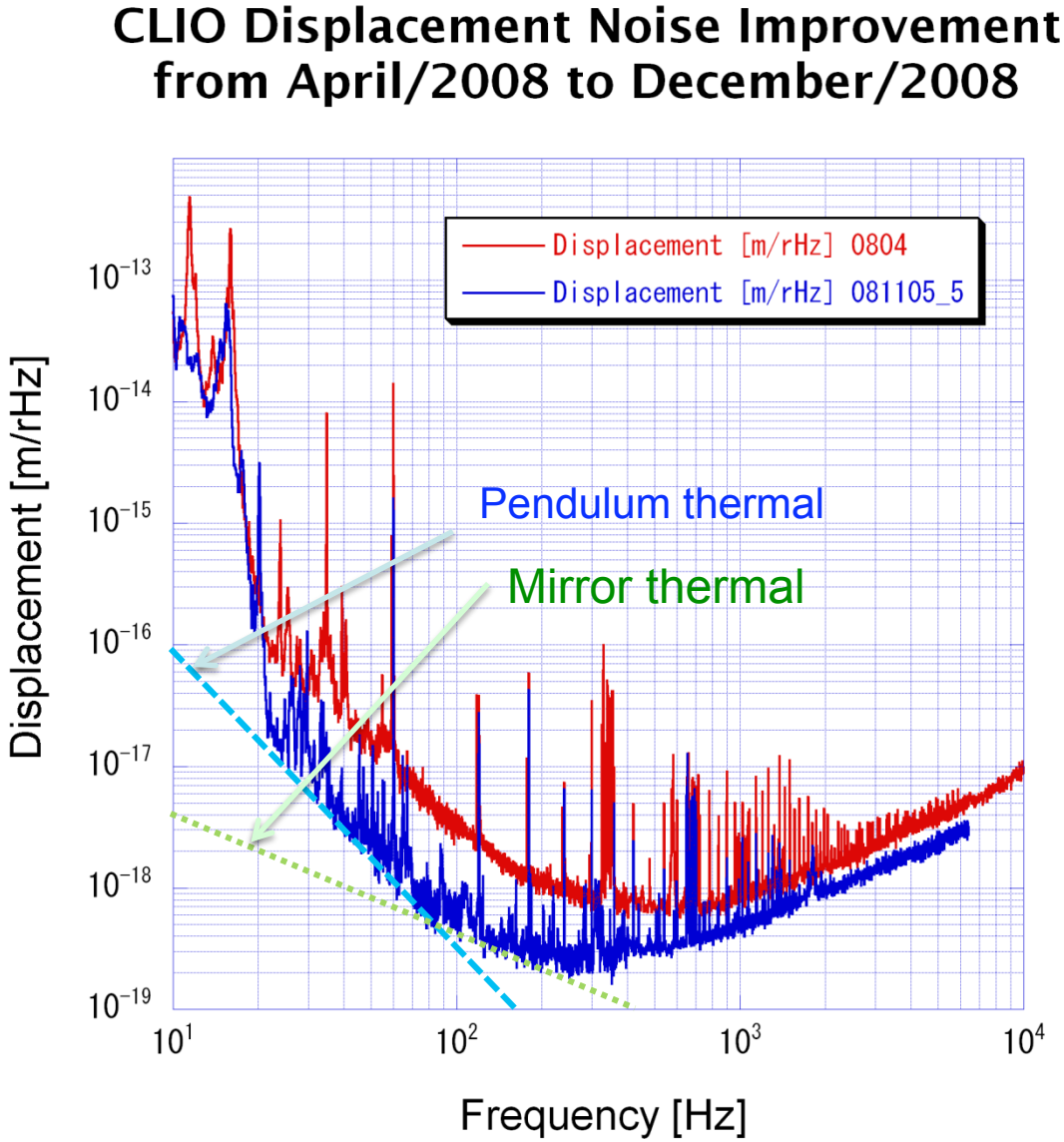
Laboratories underground, in Kamioka mine

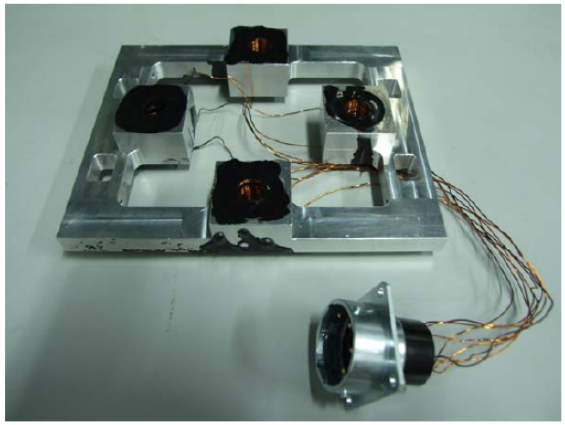


CLIO in Kamioka mine

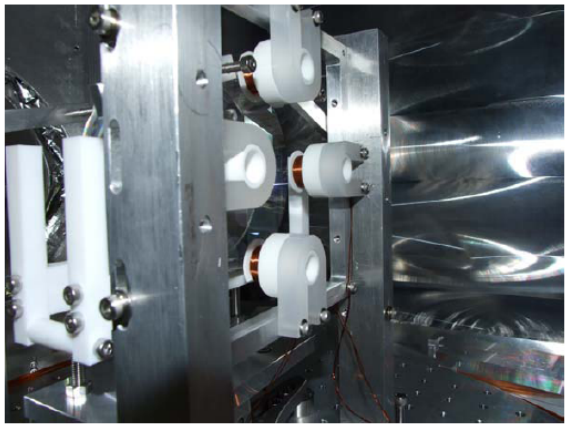


CLIO reached to thermal noise in the room temperature



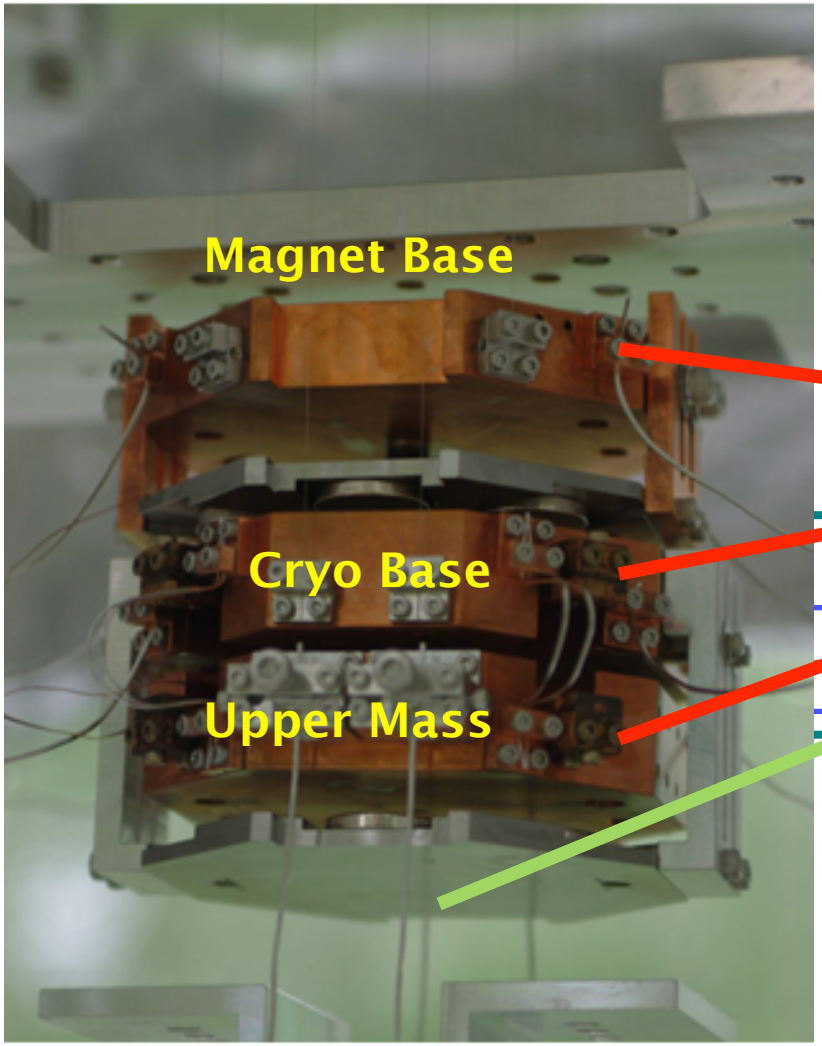


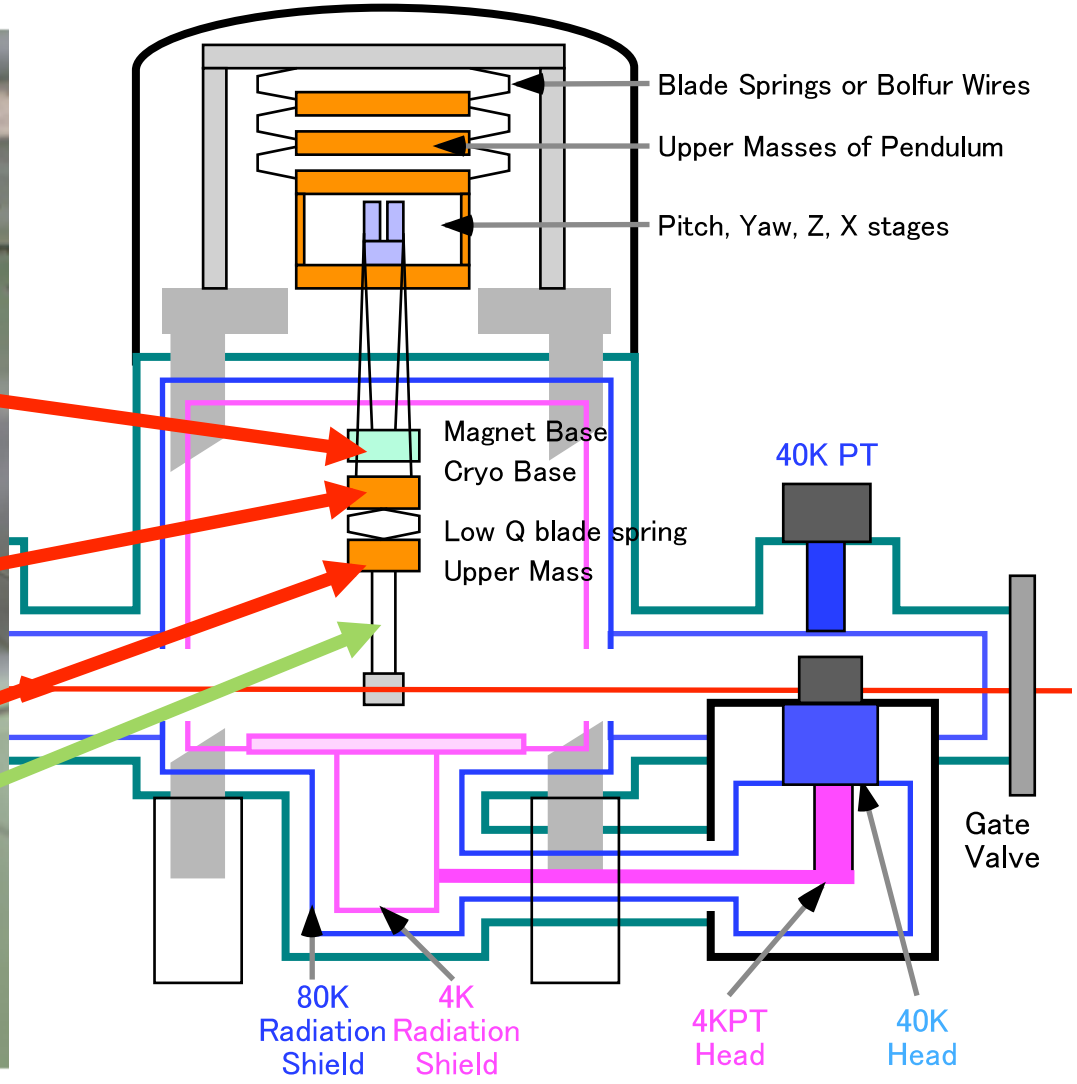
Problem: Eddy current in aluminum coil holders induced by magnets attached on mirror added mechanical loss on pendulum thermal noise



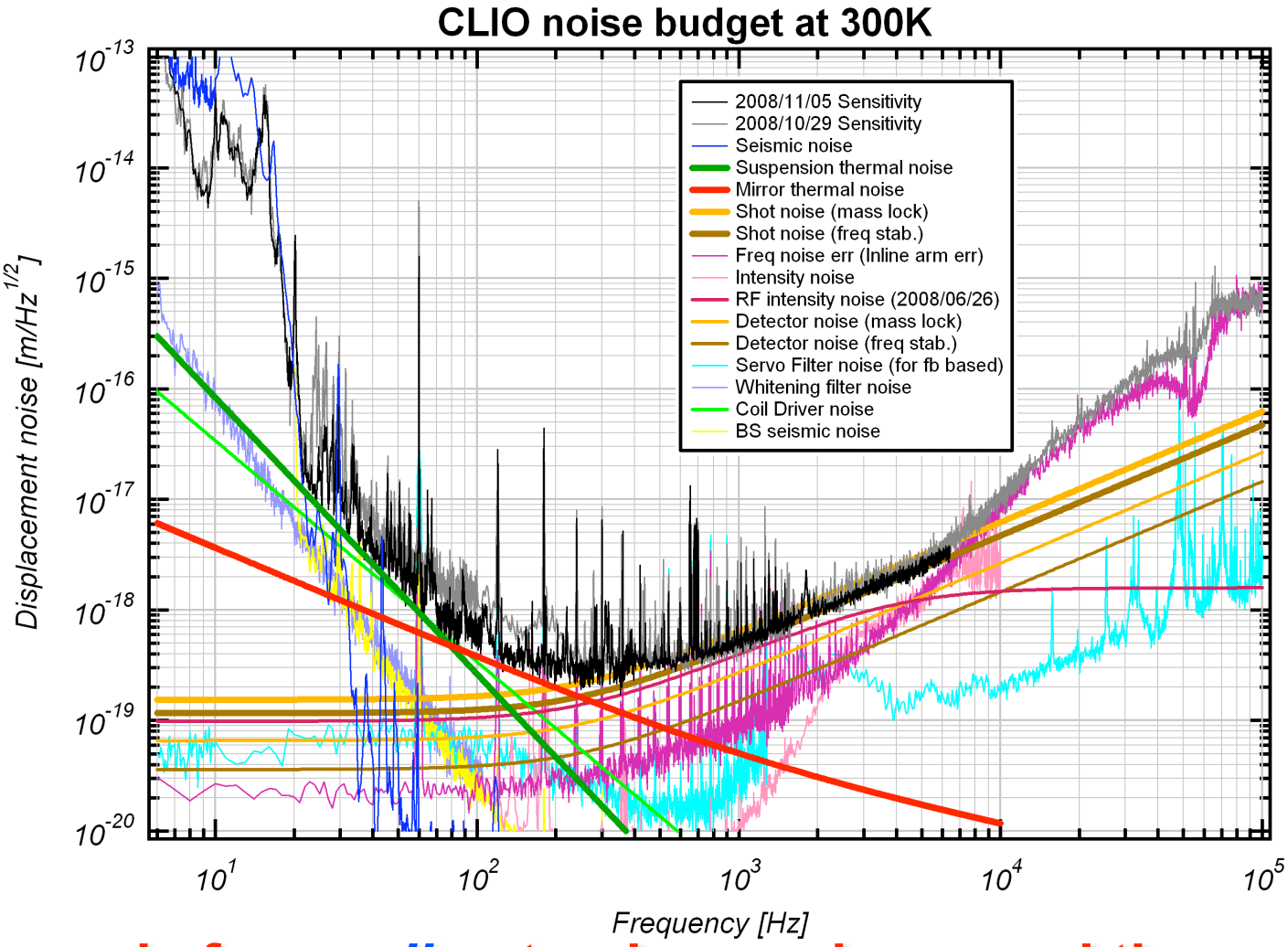
Solution: Aluminum holders were exchanged to ceramic and daifron holders.

CLIO seismic attenuation for cooling





Noise budget



We are ready for *cooling* to observe improved thermal noise!

Summary

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

- Invited a new PM for prject enhancement

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