LSC-Virgo Meeting
22-25 October, 2007

Status of the Japanese Ground Projects

Kazuaki Kuroda
TAMA/CLIO/LCGT Collaboration
ICRR, University of Tokyo

LIGO-G070709-00-Z

Status of TAMA

TAMA300

- **TAMA project (1995～)**

  Consortium of domestic research organizations

  (NAO, Phys.UT, ICRR, KEK, ERI, UEC, Adv.Mater.UT, Tokai U, TEU, NRLM, Kinki U, Kyoto U, Osaka U, Osaka CU, Astron.UT, Niigata U, Tohoku U, Hiroshima U, Hirosaki U, …)

Construction of TAMA300

R&D for LCGT

Practical detector (Observation of our Galaxy)

Sensitivity to detect
Galaxy events
(World best in 2000-2002)
Earlier observation run
(Obs data more than 2000 hr)

Observation Summary

TAMA data-taking runs including long-term observations

Run	Term	Year	Live Time (Hour)
DT1	6-Aug → 7-Aug	1999	7
DT2	17-Sept → 20-Sept	1999	31
DT3	20-Apr → 23-Apr	2000	13
DT4	21-Aug → 4-Sept	2000	161
DT5	2-Mar → 8-Mar	2001	111
DT6	15-Aug → 20-Sept	2001	1038
DT7	31-Aug → 2-Sept	2002	25
DT8	14-Feb → 14-Apr	2003	1158
DT9	28-Nov → 10-Jan	2004	558

In 1999, TAMA started to make observations

The world best sensitivity

Continuous observation more than 1000 hr with the highest sensitivity.

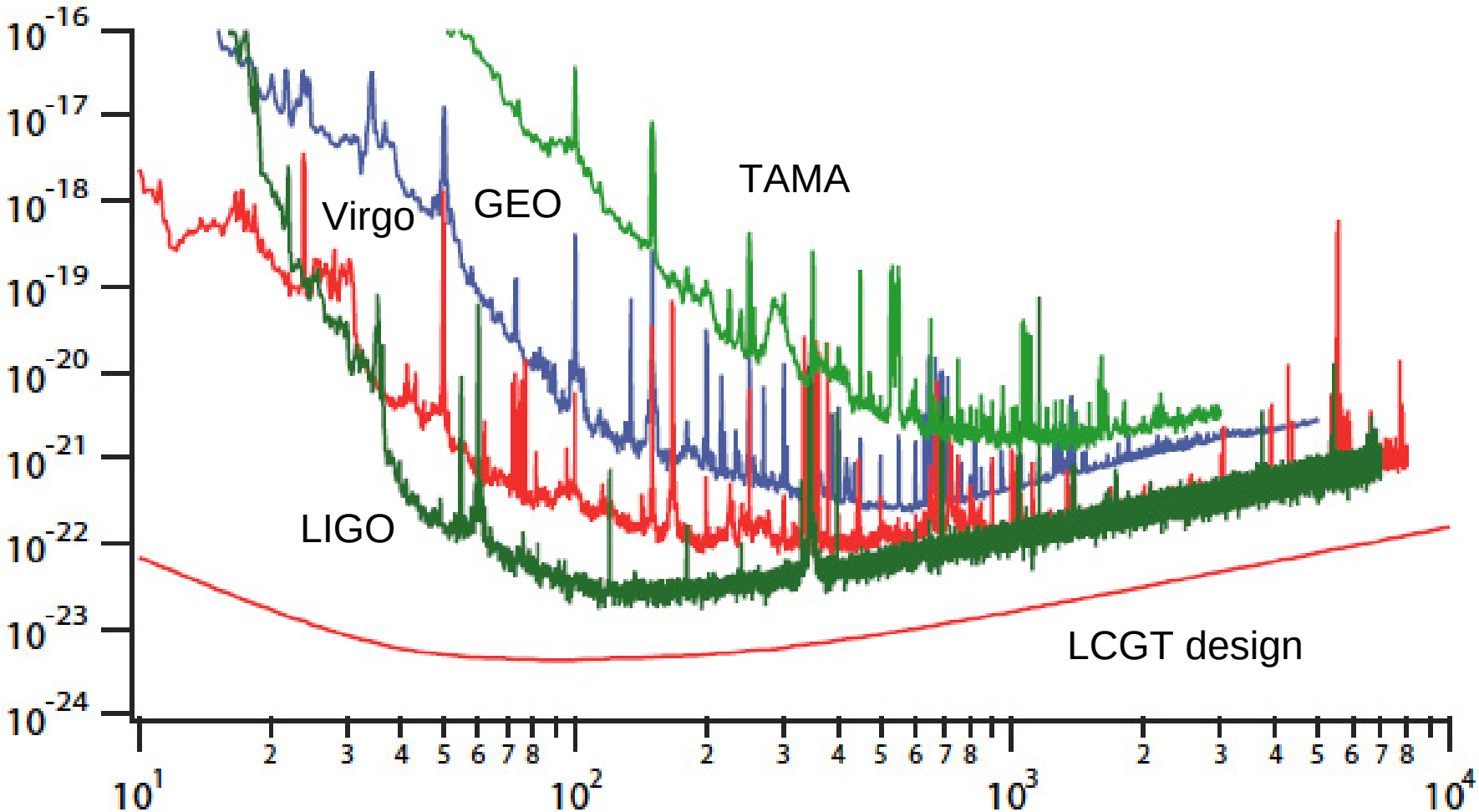
Power recycling

LIGO S1

Total 3102 hours data was accumulated.

Some parts of DT7-9 are overlapped with the science runs of LIGO (GEO) and cooperative two papers have been published to limit the event rates of both coalescence and supernova events in our Galaxy.

Sensitivity of TAMA compared with other interferometers



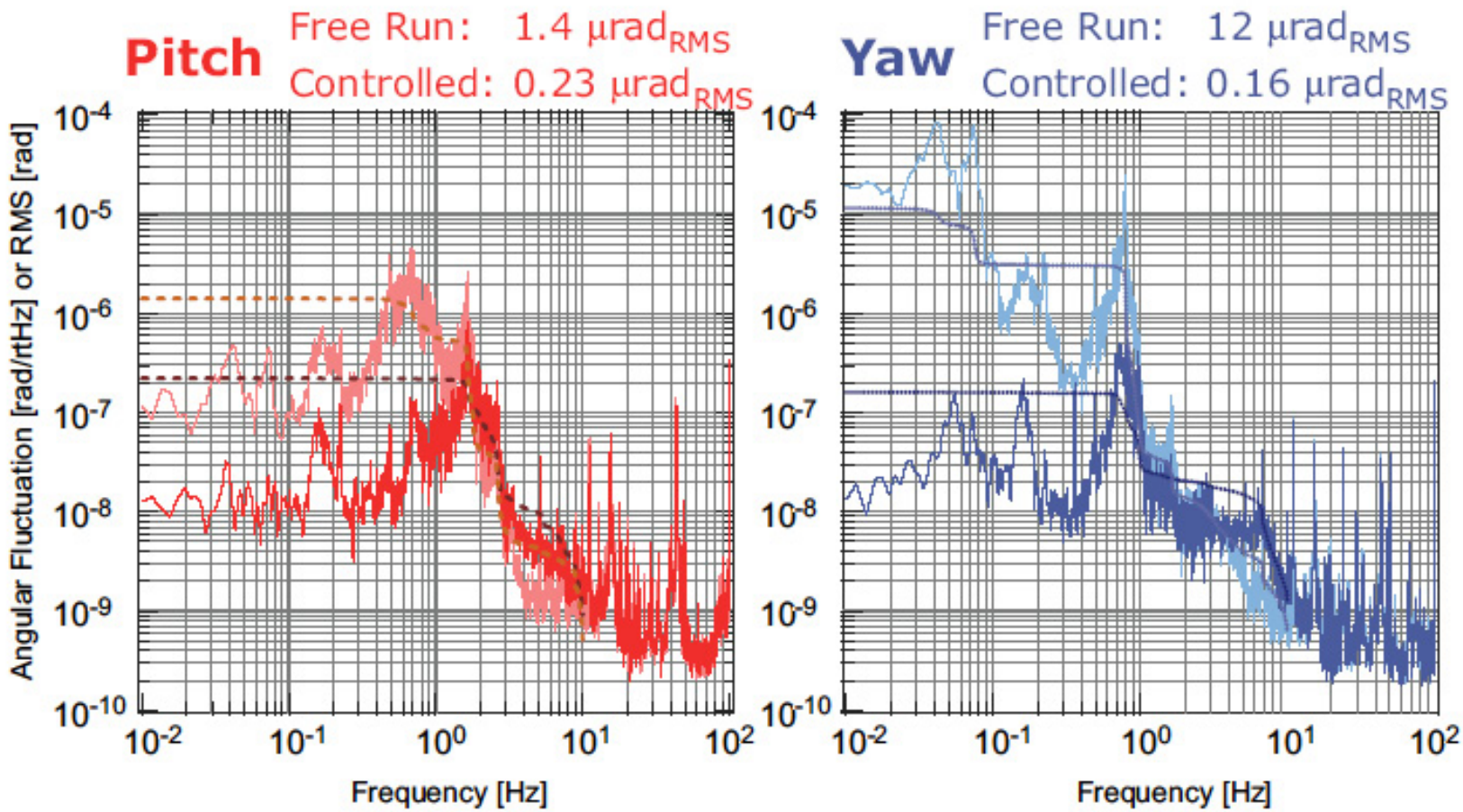
Performance of SAS

- **Test mass angular motion**

Mirror angular motion: sub-μrad_{RMS}

=> Sufficiently stable for interferometer operation

(with previous suspension system: 1.0 μrad_{RMS})

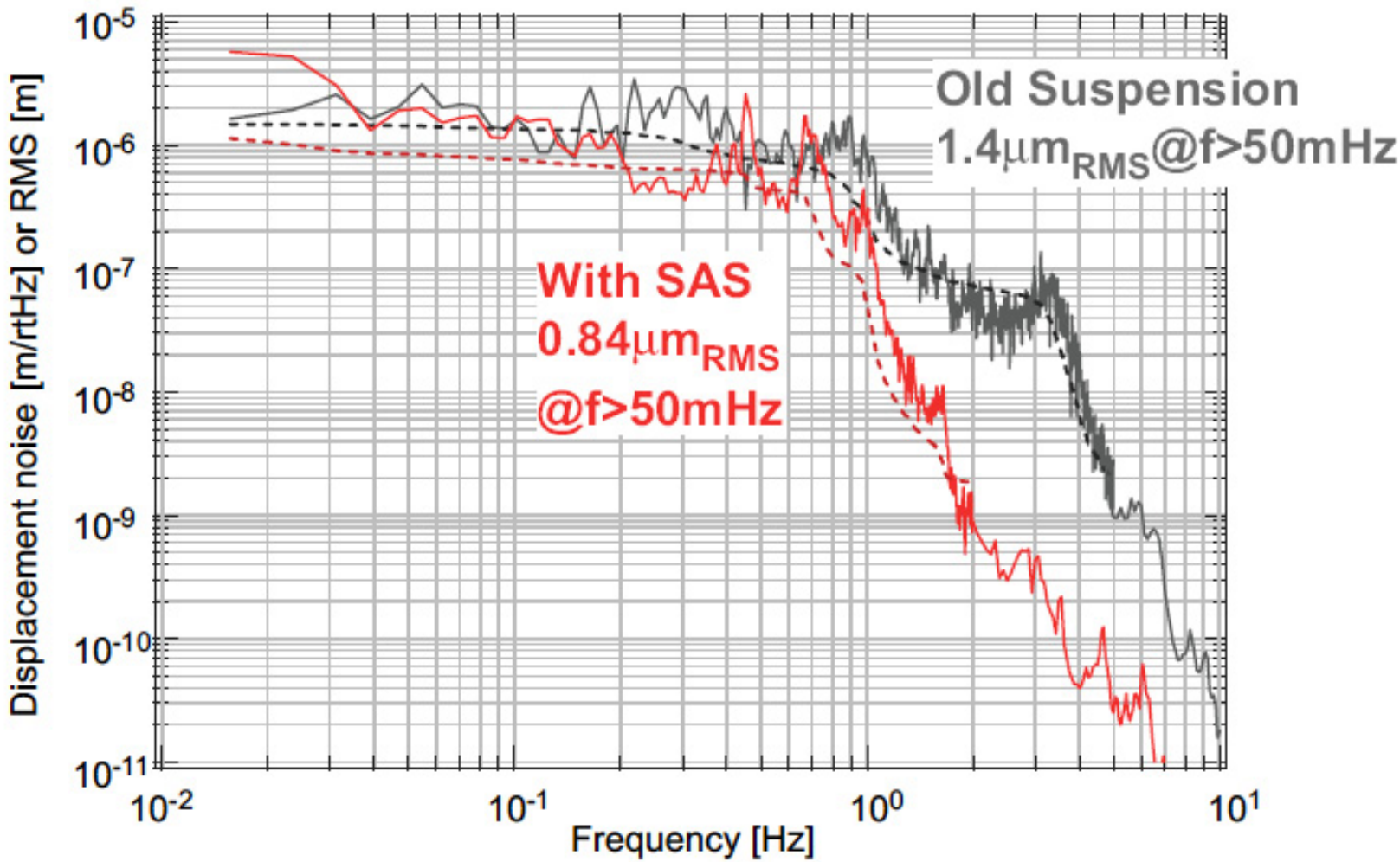


Performance of SAS

- **Legth Fluctuation of 300-m arm**

Comparison with the previous suspension system

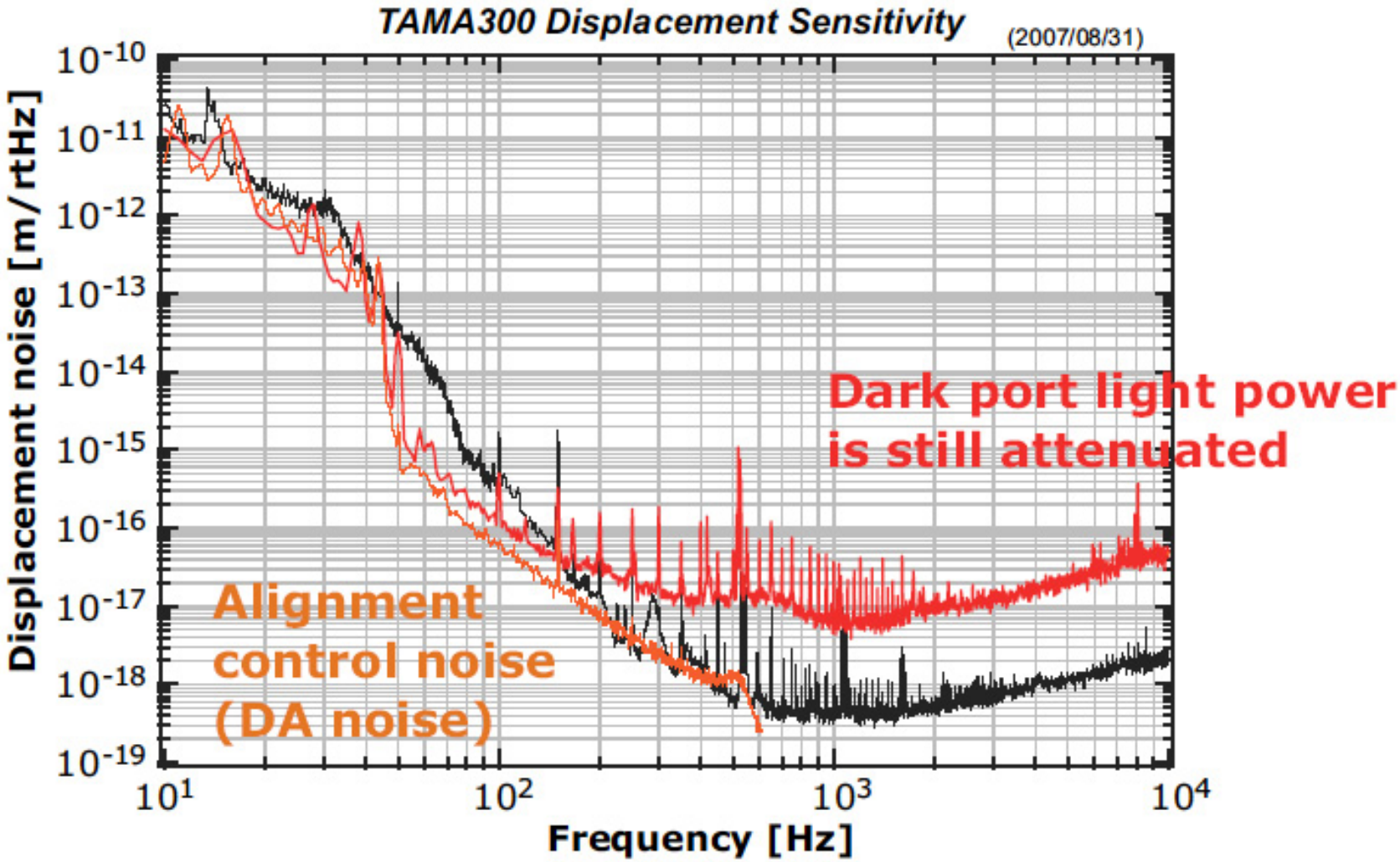
=> **improvement above 0.1Hz was confirmed**



Sensitivity

- **Tuning of the system still underway**

  So far, improvement below 150Hz was confirmed



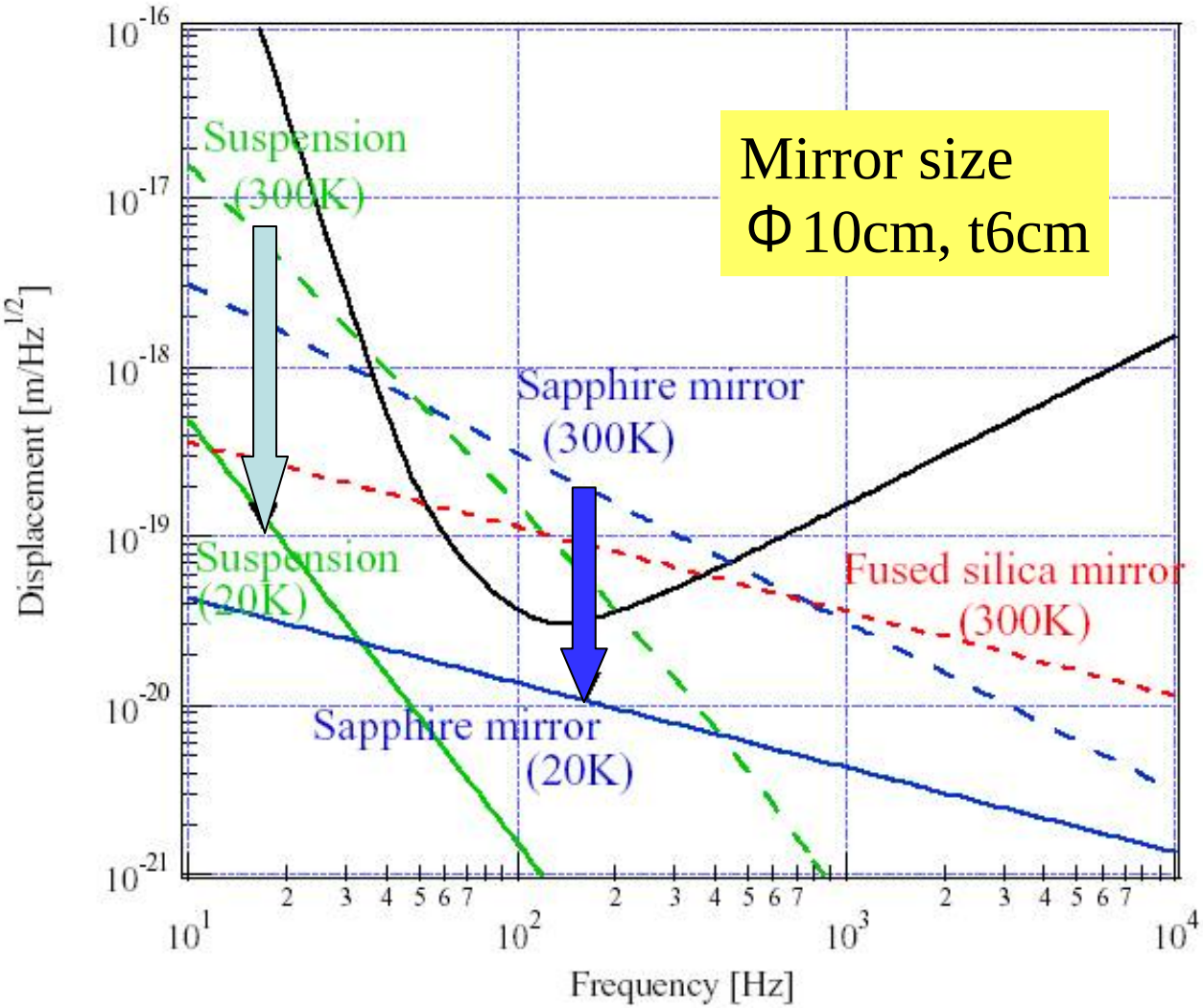
K.Arai - TAMA Project

TAMA Summary

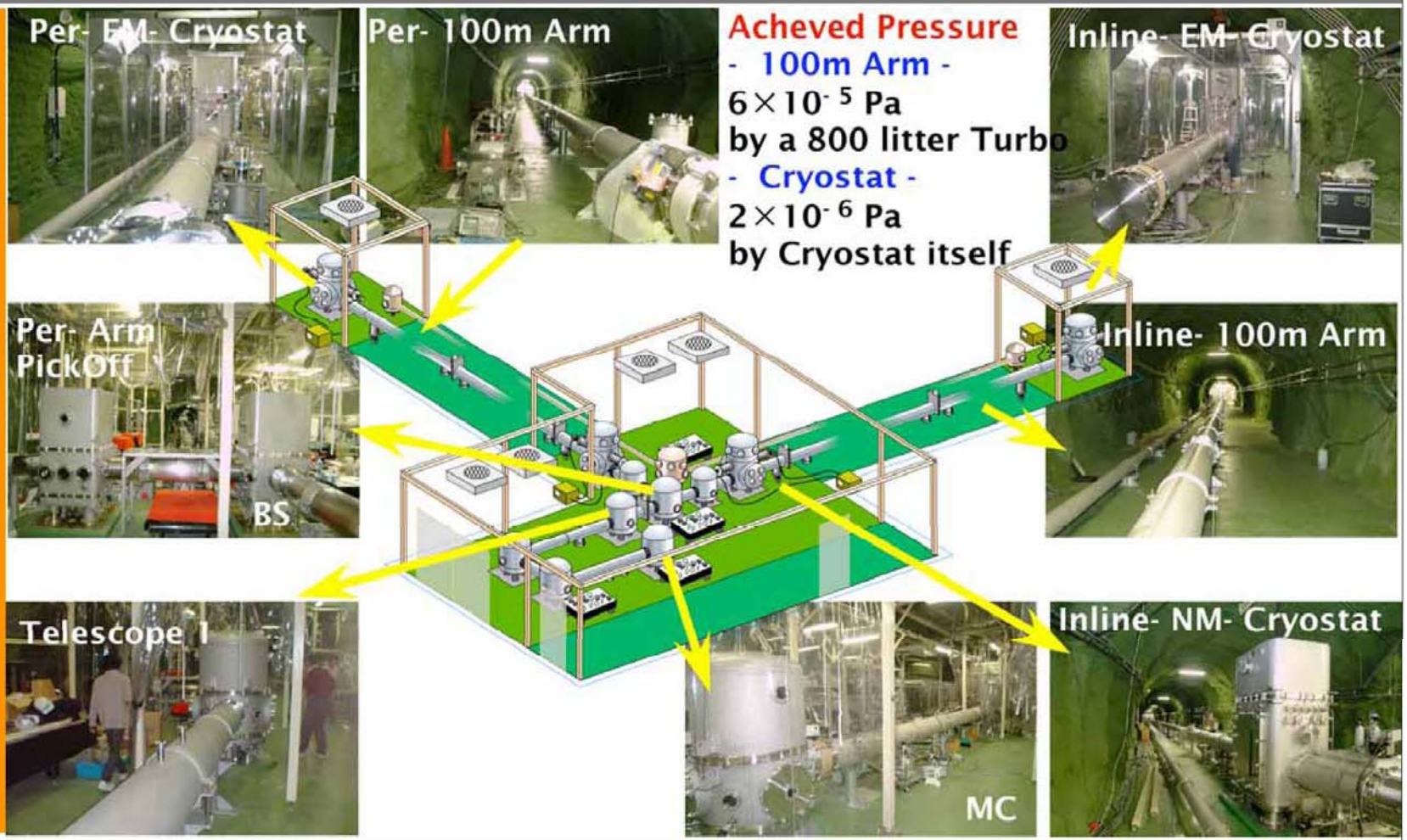
- We are trying to achieve the target sensitivity of TAMA at low frequencies using SAS
- SAS has been installed as planed and its performance has been tested at first time
- DSP is partially used for lock acquisition
- More time is needed to obtain the final sensitivity

CLIO Sensitivity Improvement

Expected reduction of thermal noise by CLIO (300K – 20K)

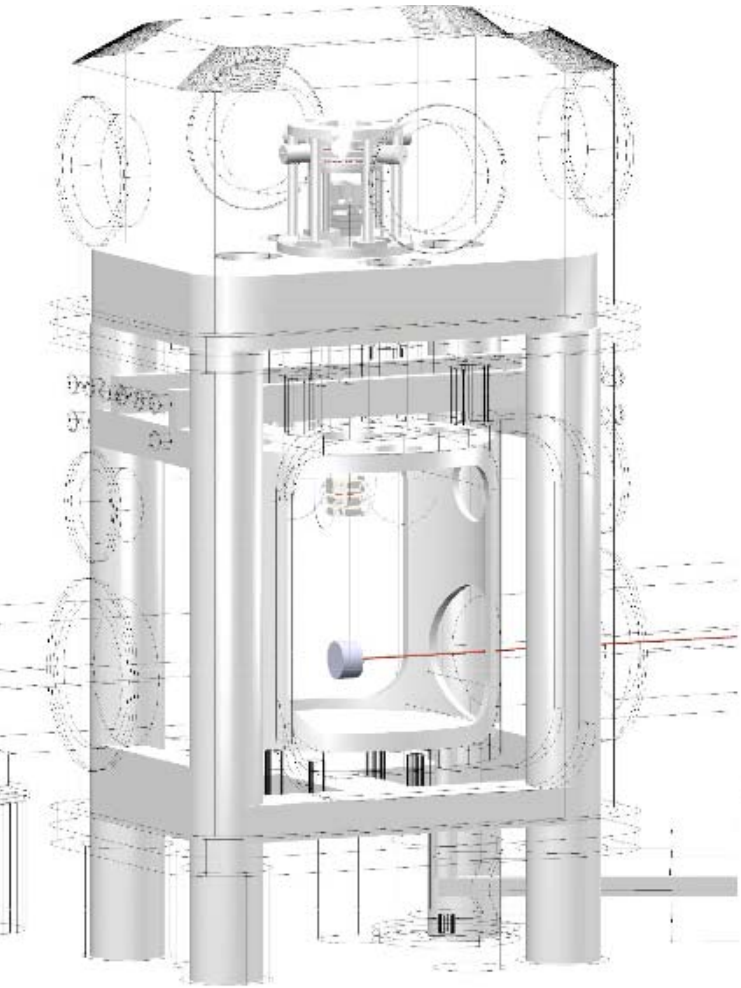


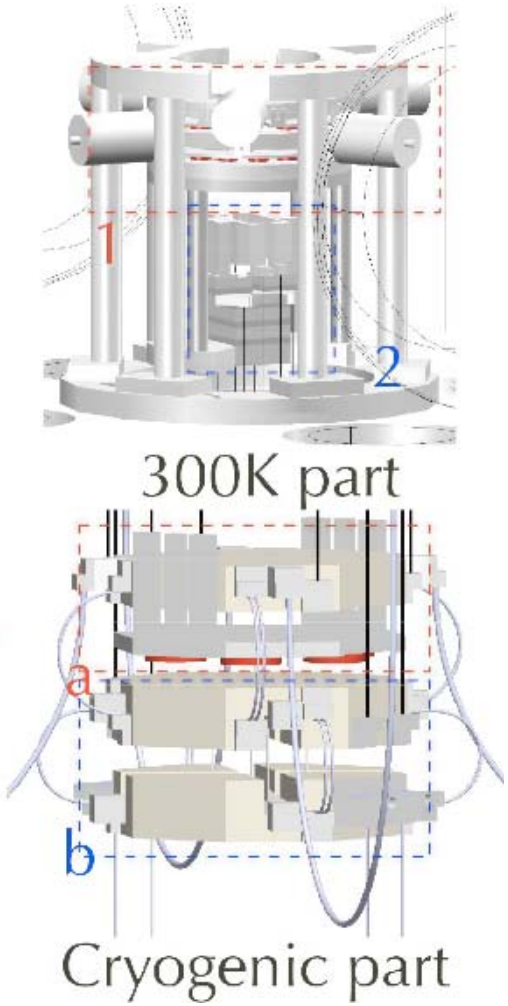
Construction of CLIO



by Miyoki

Sapphire Mirror suspension system





Height: 1.5m.

Weight: 21kg.

1: Three stages of vibration isolation system.

2: Mirror alignment stage.

a: damping stage.

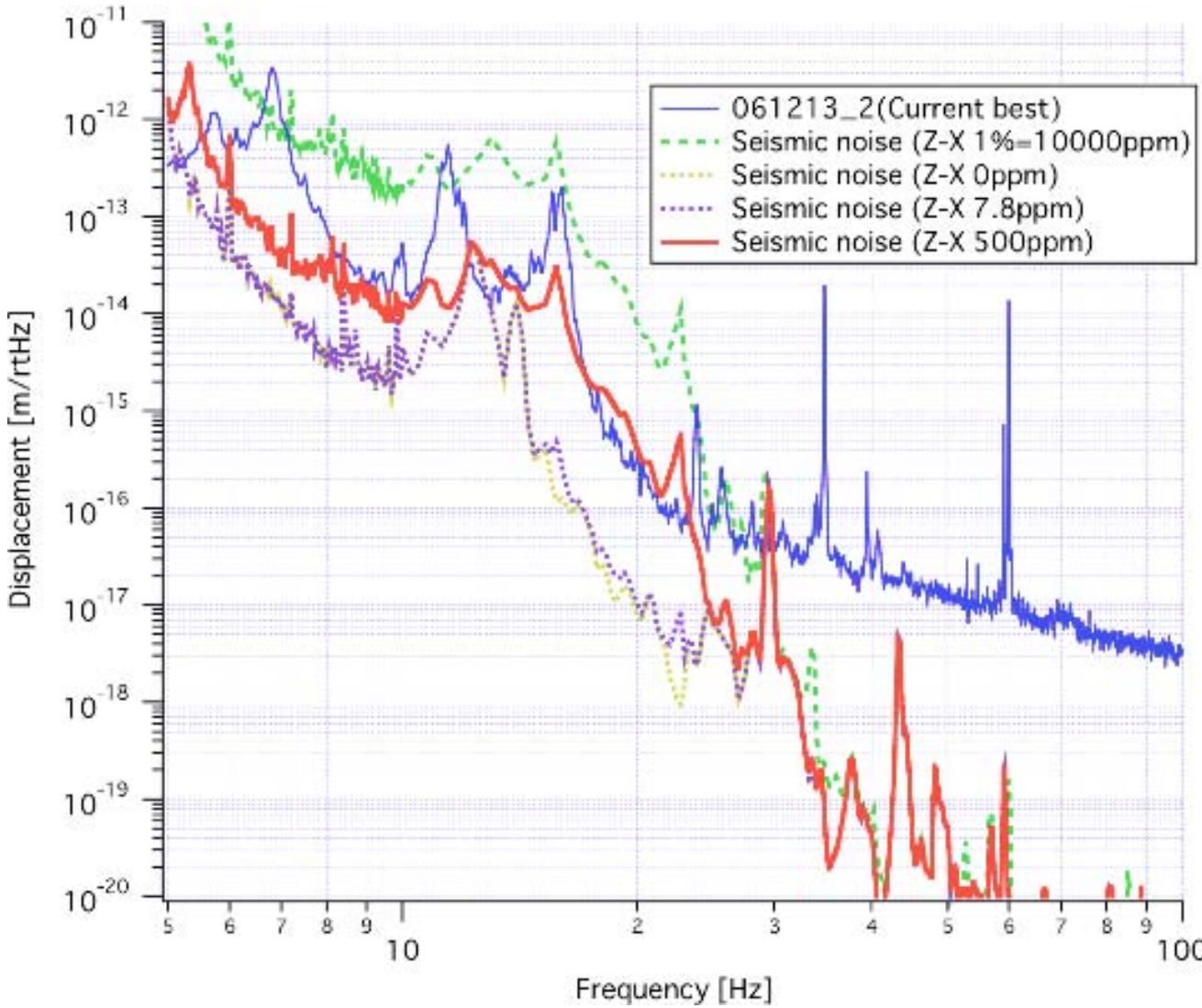
b: cryogenic masses.

by Uchiyama

Sensitivity in low frequency region - seismic noise -

- Why is the sensitivity better than the target?

* Lower Z-X coupling may be realized than design value of 1%.

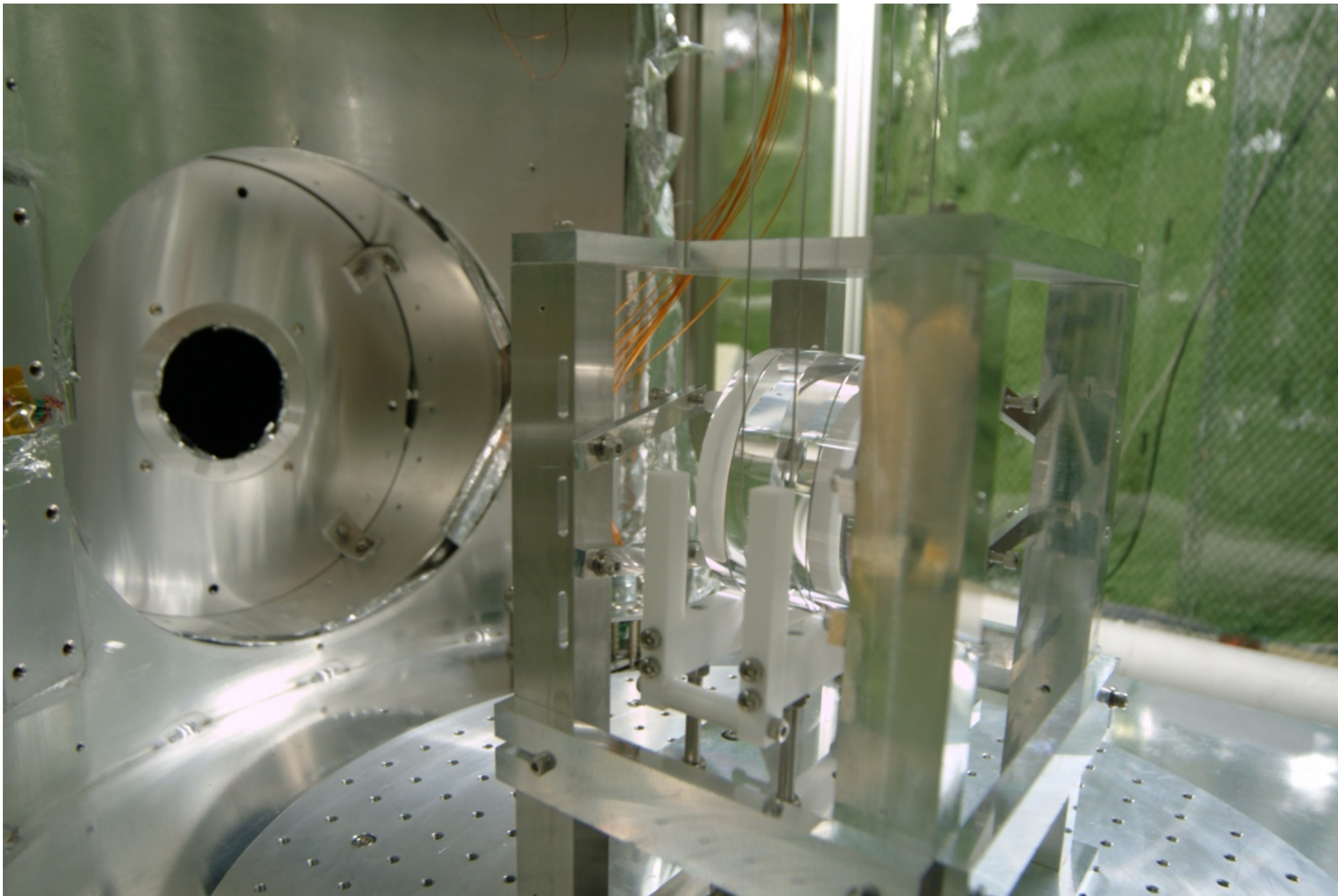


by Uchiyama

For cooling

Thermal radiation incoming from the duct was needed to shield covers.

Without shield covers the mirror looks like this



Summary of cooling

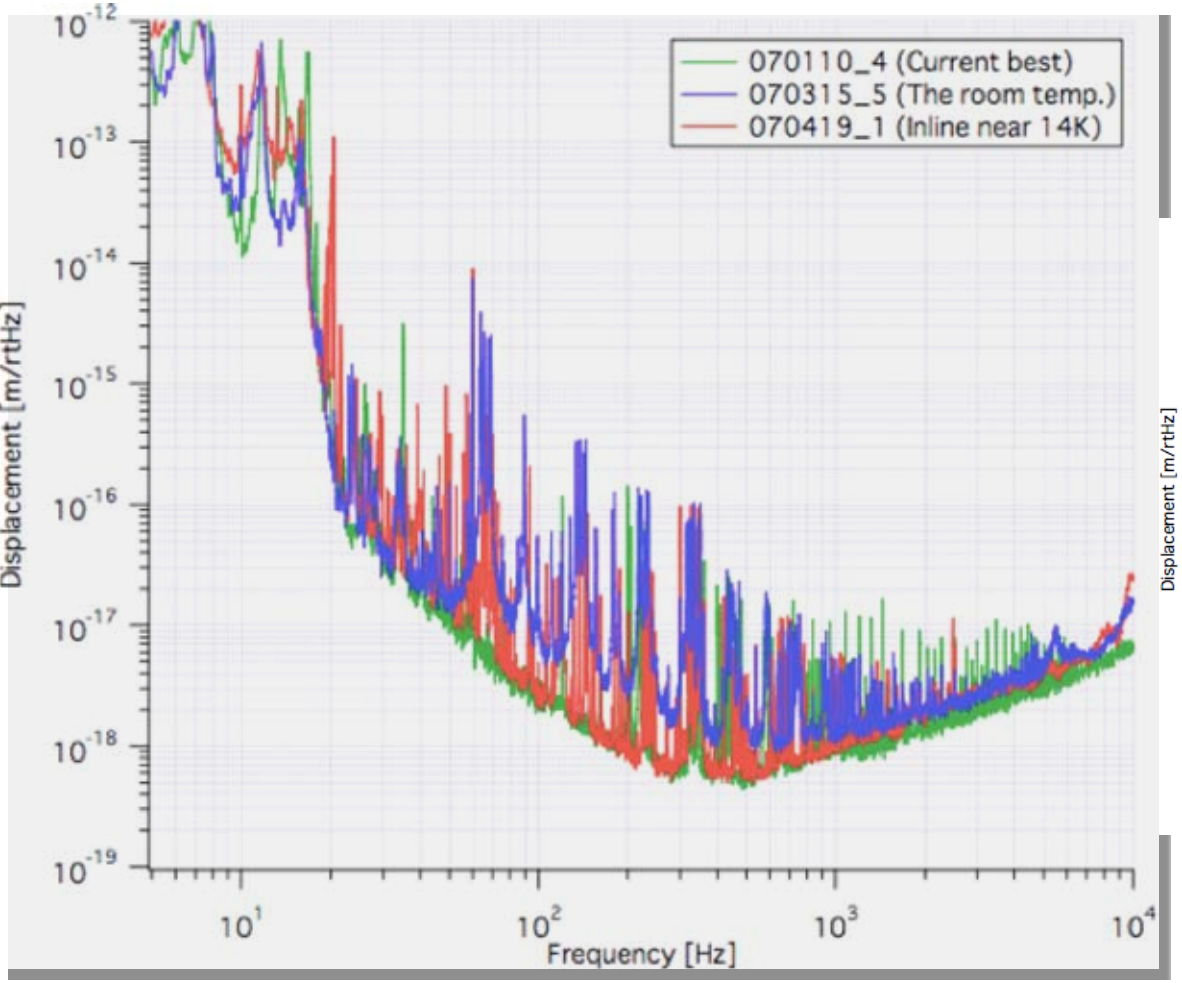
Mirror	Cooling time	Mirror temp	Heat in the suspension	Heat at the 1st cooling 2006/02
Inline end	176hour start 07/06/22,10:00	13.5K	40mW	N/A
Inline near	174hour start 07/06/22,10:00	13.4K	36mW	N/A
Per arm end	164hour start 07/04/27,11:05	12.5K	62mW[#1]	116mW
Per arm near	193hour start 07/08/16,12:30	13.8K	29mW	109mW

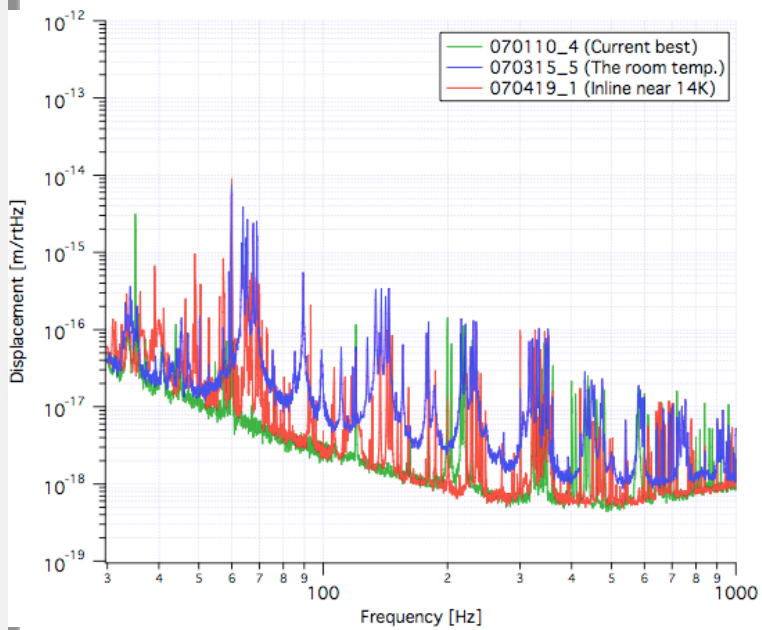
#1; No shield for radiation from the outer shield at 63K.

by Uchiyama

by Uchiyama

Sensitivity - Test cooling-

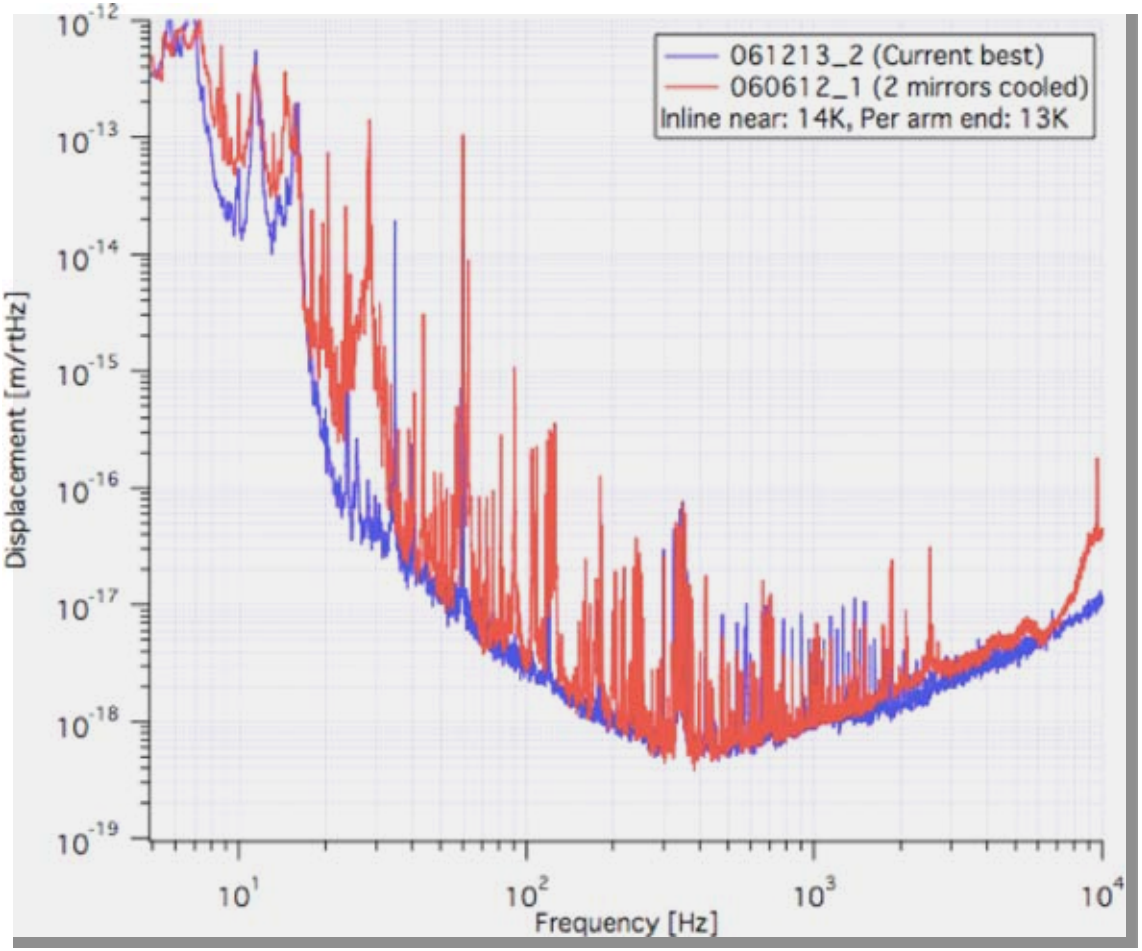


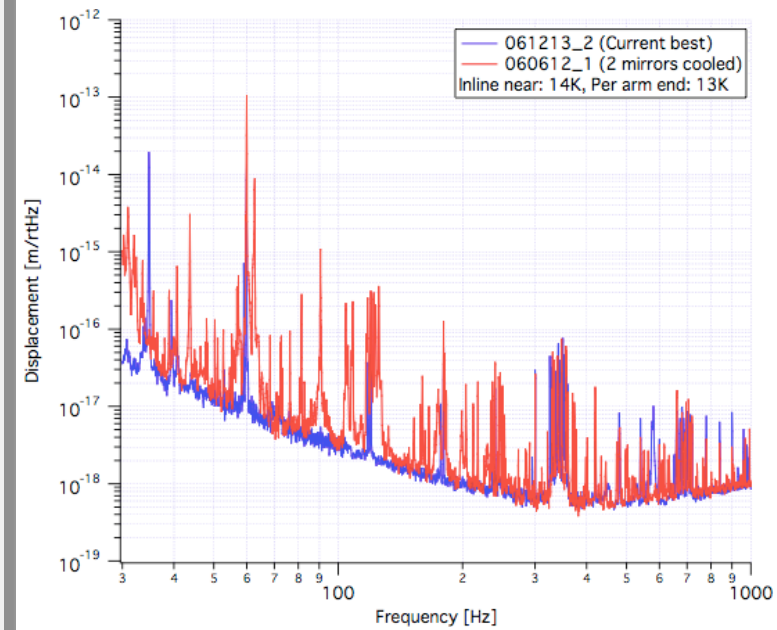


Inline near mirror was suspended by Φ1.0 Al wire.

This is the first observation of sensitivity improvement by cooling.

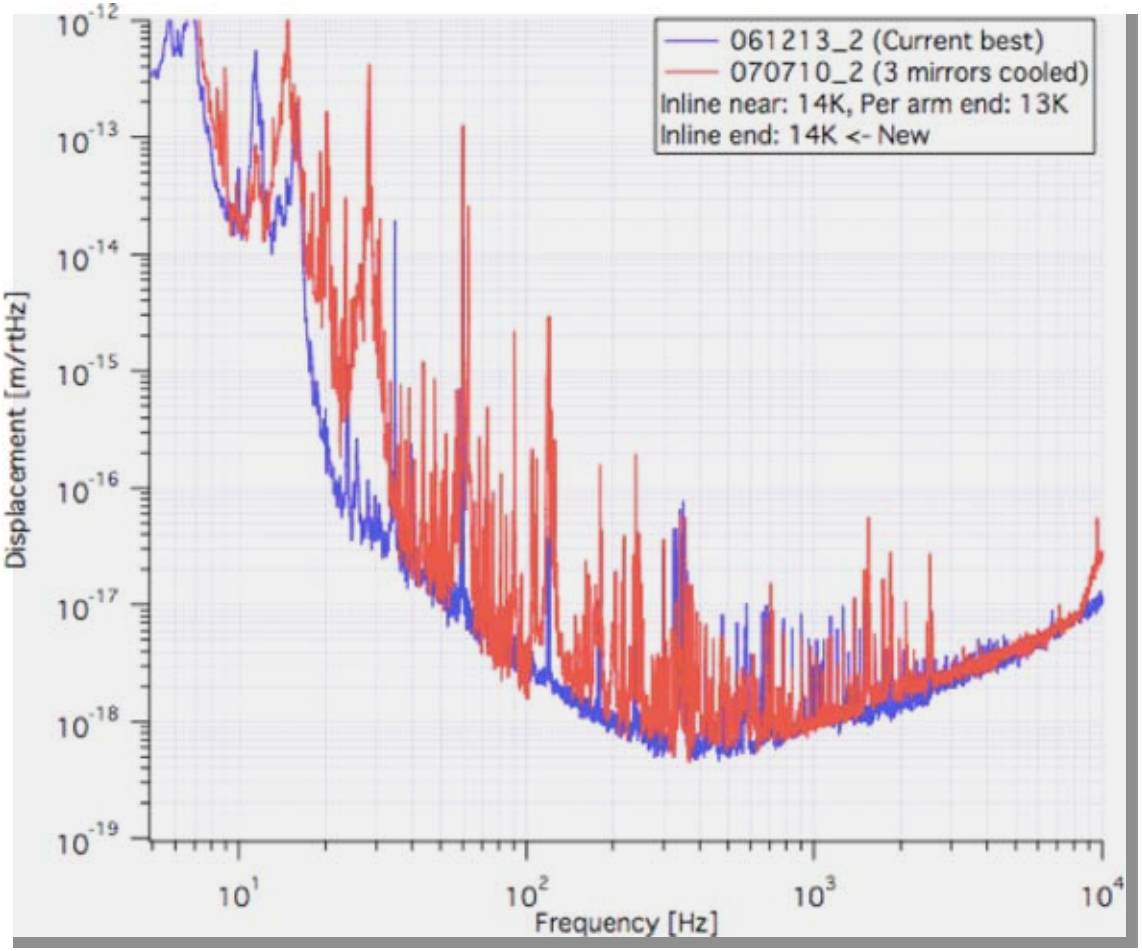
Sensitivity
- 2 mirrors are cooled -

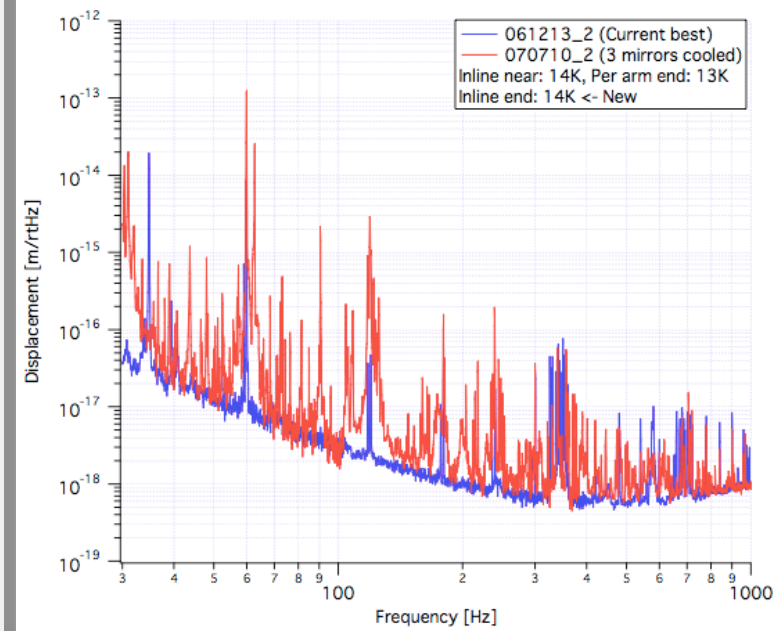




by Uchiyama

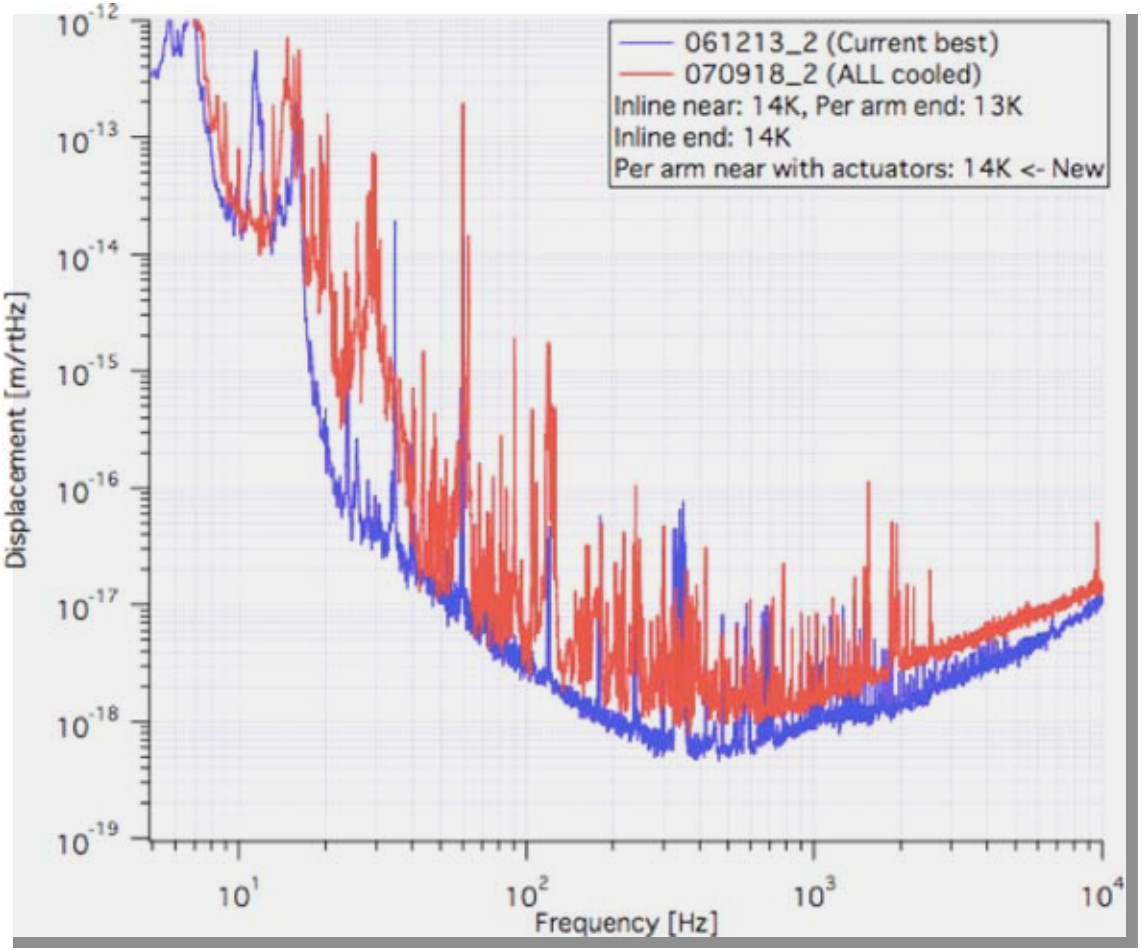
Sensitivity
- 3 mirrors are cooled -

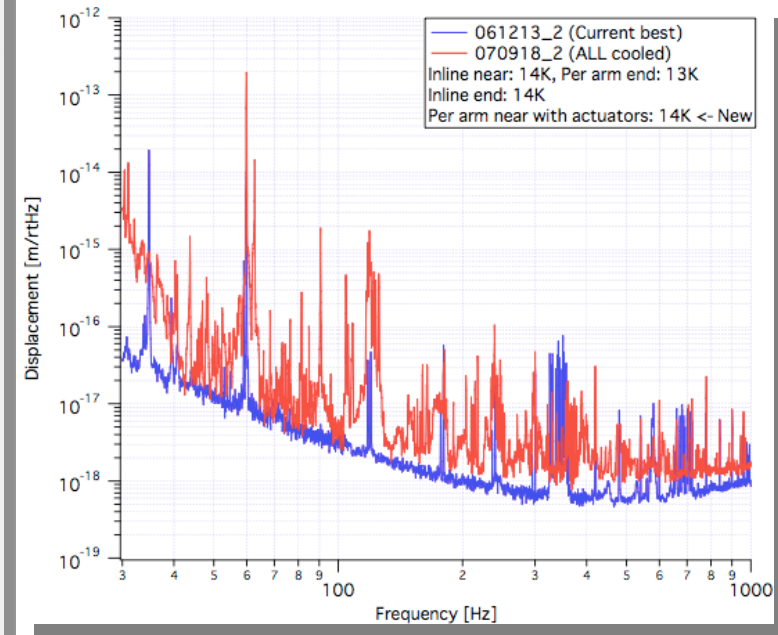




by Uchiyama

Sensitivity
- All mirrors are cooled -





Tuning has not finished yet.

by Uchiyama

Summary of CLIO

The unknown noise of f^{-2} dependence is still serious problem to reach the thermal noise at cryogenic temperature. We believe it does not originate from cryogenics.

All mirrors have been successfully cooled at 12-14K.

Sensitivity of cryogenic operation is close to the current best of 300K operation, even though there are a lot of structure.

LCGT

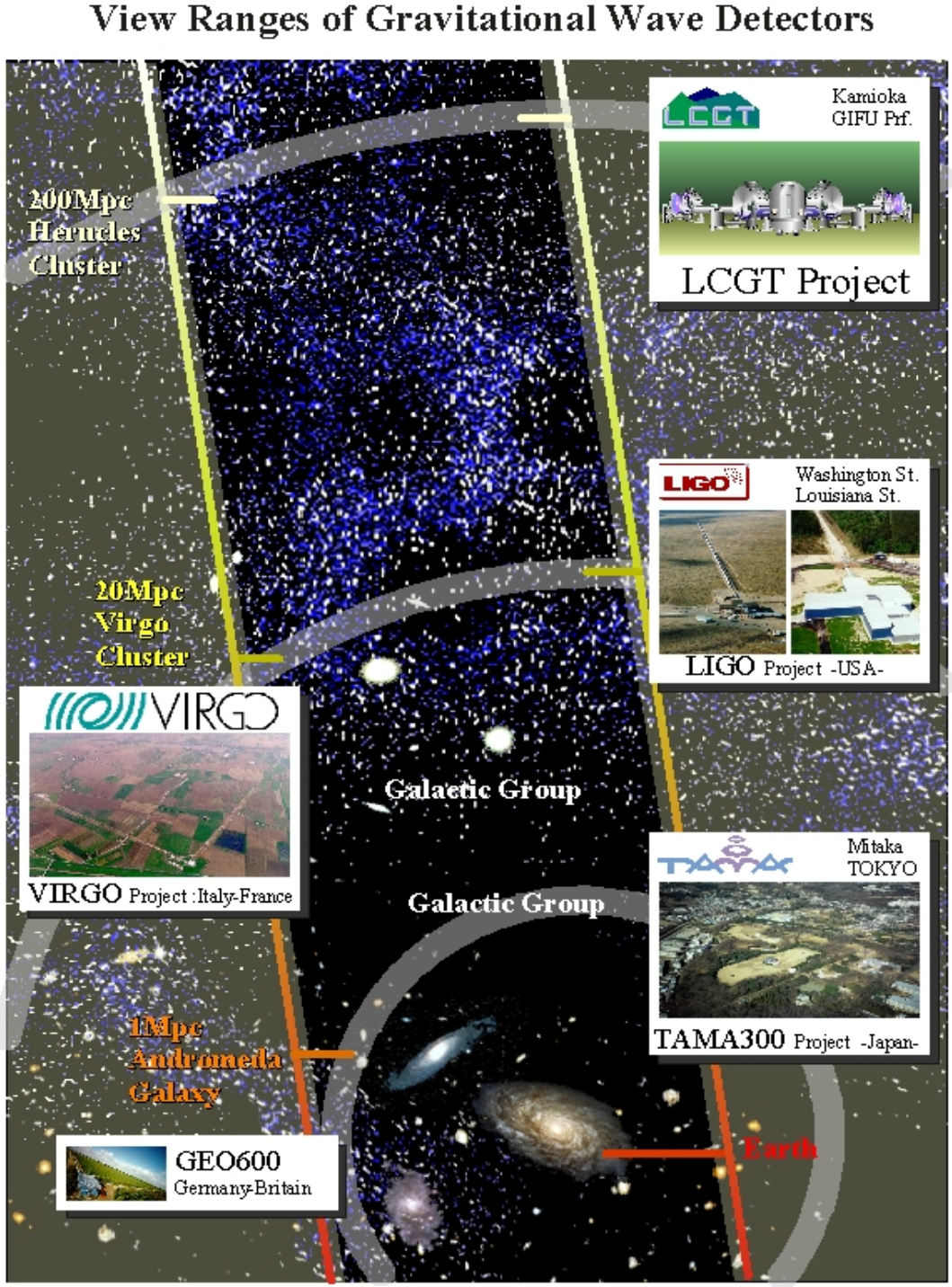
Necessity of LCGT

LIGO (USA), VIRGO (French-Italian), GEO (Germany-England), TAMA (Japan) are in operation.

Occurrence of neutron star binary is estimated to be 10^{-5} for matured galaxy per year. There are 0.01 galaxies for 1 cubic Mpc. Present detectors (km-scale) cover up to Virgo cluster（20Mpc). More than several years are needed to detect the event.

Therefore, we need more sensitive detector. LCGT can detect an event occurring at 180Mpc on average and observes 8 events a year.

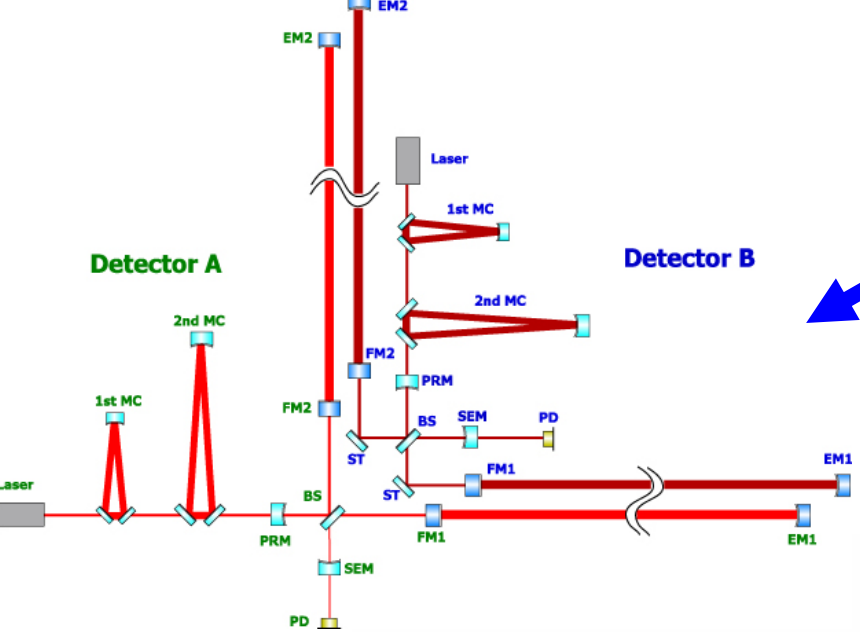
1pc=3.3light year

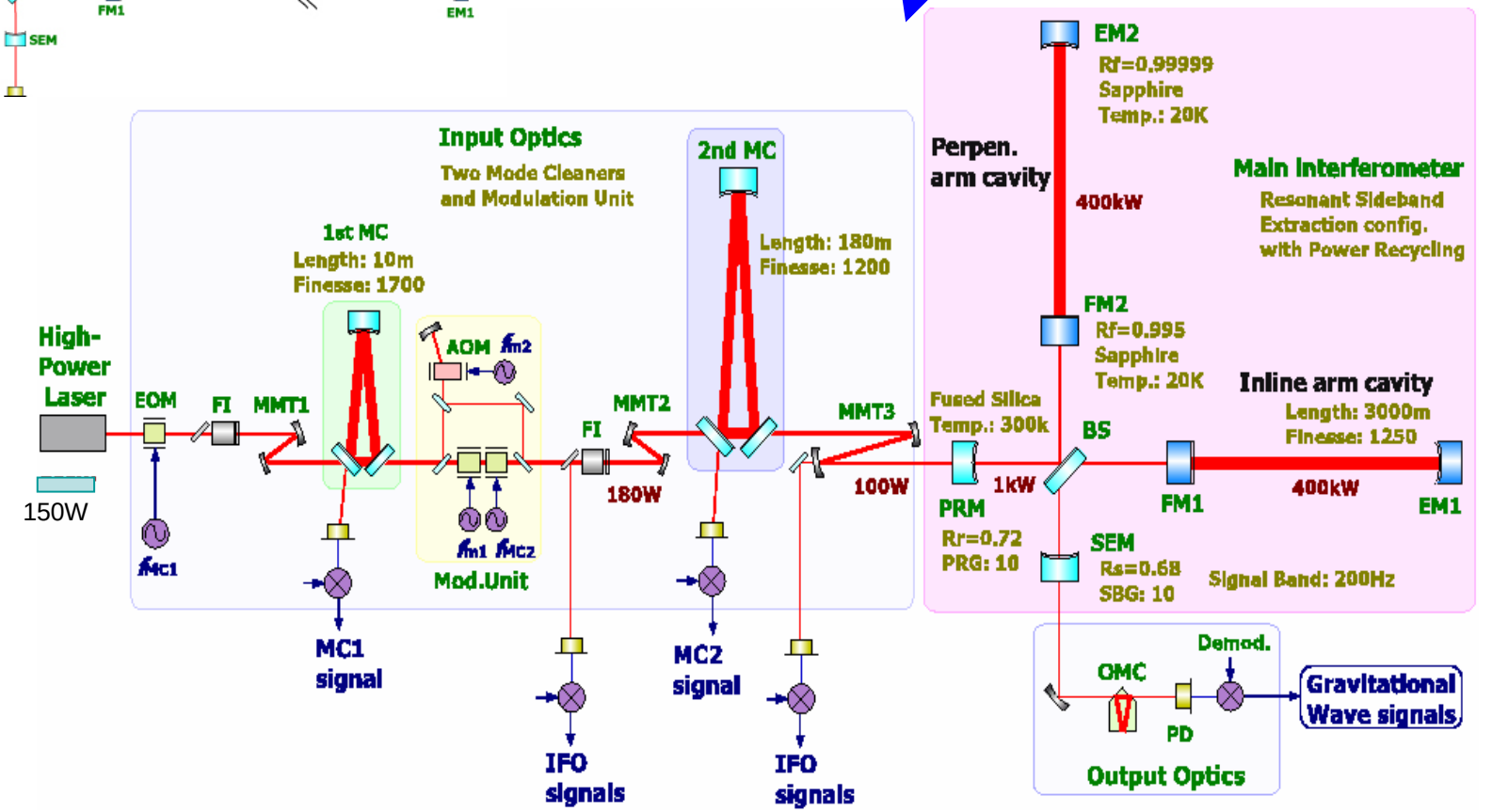


Optical design of LCGT

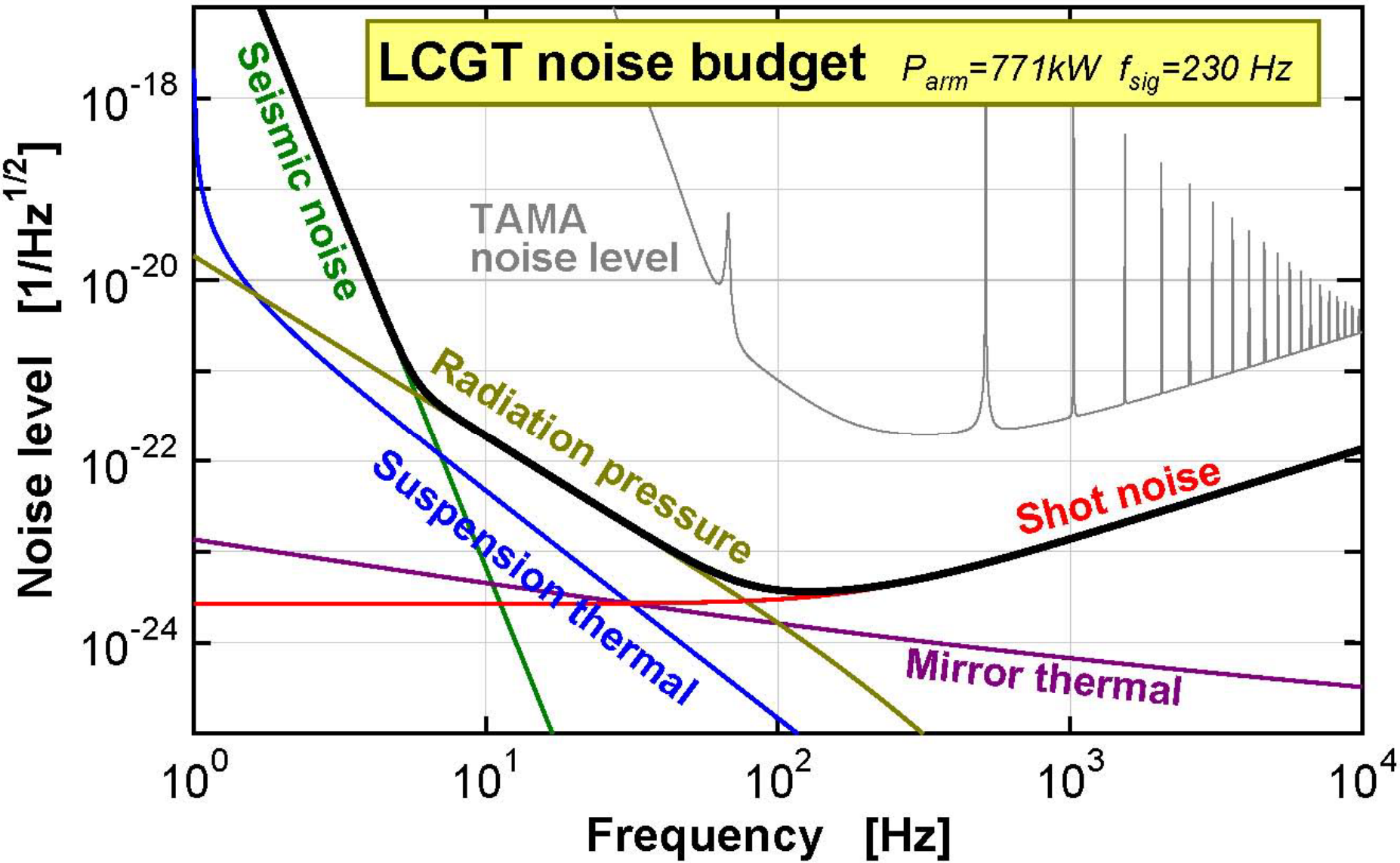
Two interferometers are arranged not to interfere in the same vacuum system.

Optical design of the basic interferometer



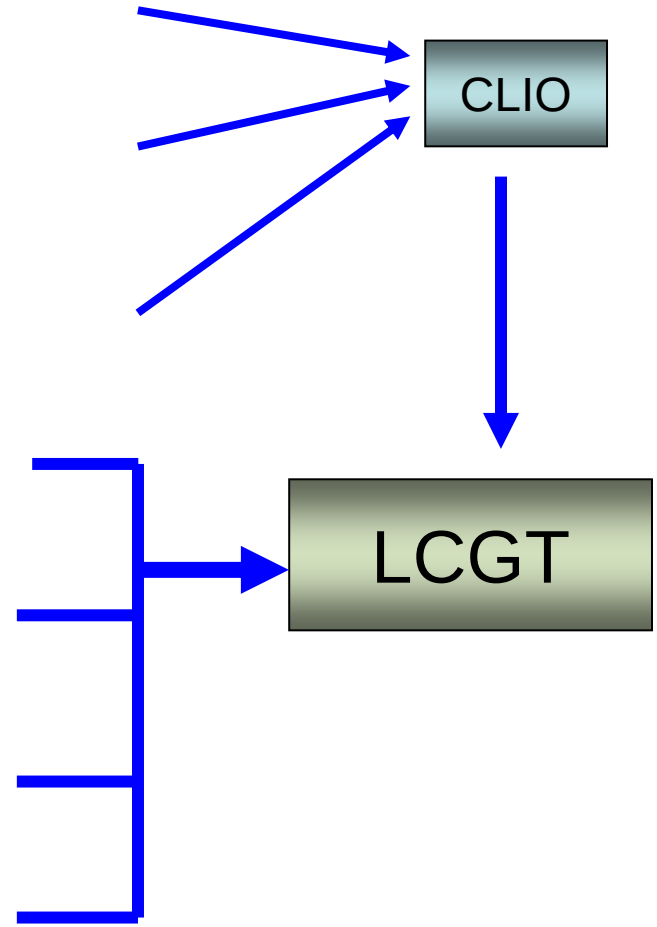


Design Sensitivity



Technical basis of LCGT

- 10m, 100m Delay-Line
  - ISAS 1992-1995
- 20m interferometer
  - Kamioka mine 1999-2002
- Cryogenic experiments
  - KEK-ICRR 1997-2002
- TAMA advancement
  - NAO 1995-
- RSE adoption
  - NAO 1998-
- SPI installation
  - Phys. Dept. UT 1999-
- SAS
  - Phys. Dept. & NAO 1998-
    (CALTECH)



Parametric instability of LCGT

- Unstable mode is fewer by 10 times than those of the advanced LIGO.
- Transverse optical modes are less dense against mirror curvature change by 30 times than adv. LIGO.
- This effectively heals the problem of parametric instability, which is the natural product of cryogenics like small thermal noise and negligible thermal lensing.

by Yamamoto in Amaldi7

Funding status

-- LCGT applied third trial to get funding for FY2009.
-- Design of LCGT has been reviewed in 2005 by the external review panel by the Institute of Cosmic Ray Research.
-- The Academic Council of Japan expressed a demand to the Japanese government to make a framework accepting a project such as LCGT.
-- However, the government postponed the work till the next March.
-- Although the University of Tokyo had submitted LCGT request to the Ministry of Education, Sports, Culture, Science and Technology, the Ministry didn't submit to the Ministry of Finance. LCGT is not nominated for FY2009.
-- So far we had been stressing the first detection of GW to get funding.
-- However, the review panel of ICRR summarized its report this spring and placed more importance of a detector with good sensitivity comparable to the advanced LIGO to be built in other places than US and Europe.
--By this recommendation, we have determined this month to repeat the request for the next year (FY2010) budget request.
-- International collaboration may be one of strong pushes of the funding.
-- I still hope LCGT will be funded in near future.

Summary

- TAMA sensitivity is steadily improved by SAS.
- CLIO confirmed underground significance again and proves the feasibility of cryogenic mirror, soon.
- LCGT has sensitivity to certainly detect gravitational wave events in a year.
- We determined to repeat the request for FY2010.