Current Status of LCGT and CLIO

Kazuaki Kuroda & LCGT Collaboration

Observed neutron star binaries

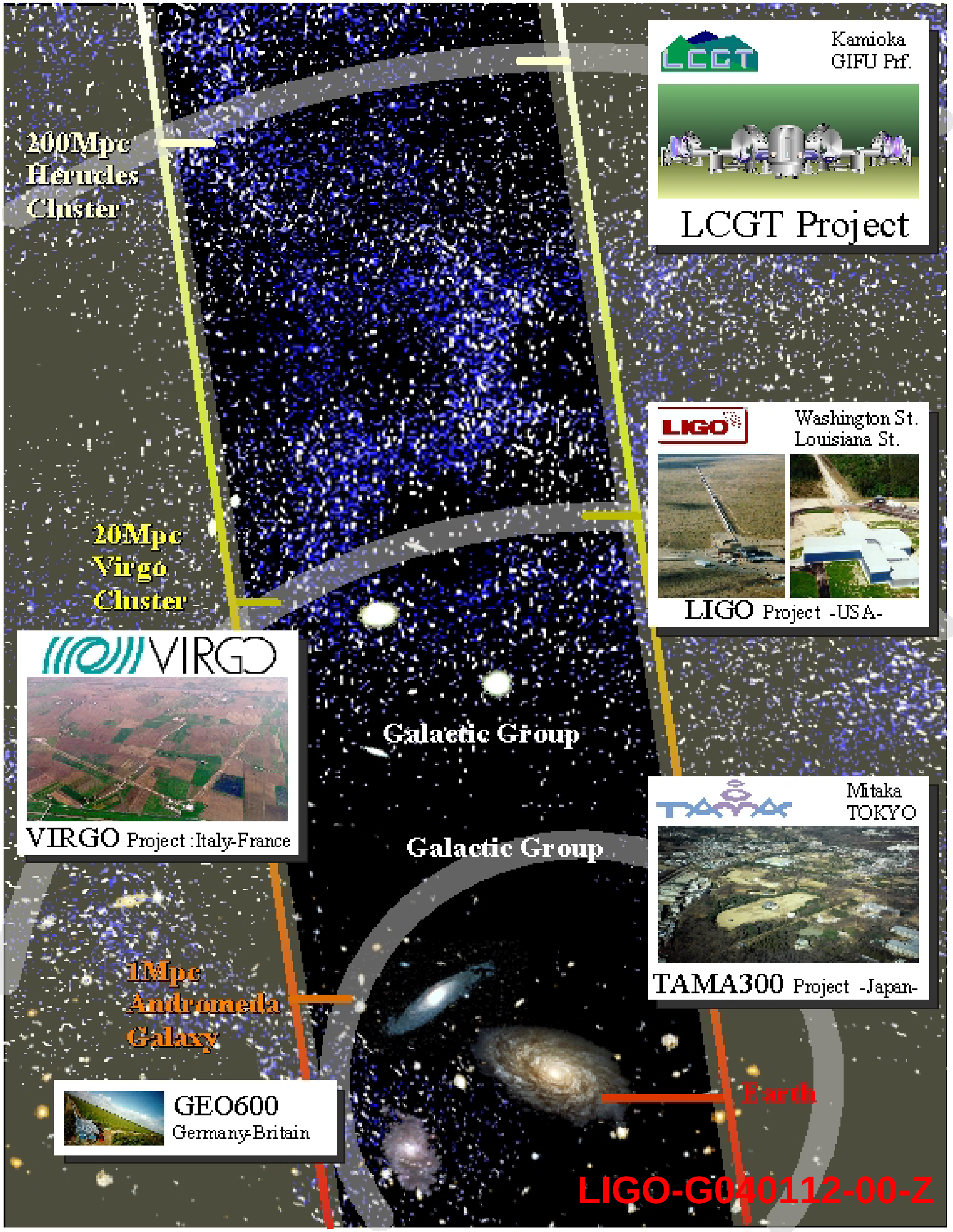
- PSR B1534+12 (0.5kpc) 10^{-6} in Galaxy
- PSR B1913+16 (7.3kpc) 10^{-7} in Galaxy
- PSR B2127+11C (10.6kpc) in M15
- PSR J0737+3039 (0.5-0.6kpc) $\sim 10^{-5}$ in Galaxy

Since BNS exist and the signal of the coalescence is precisely predicted, the event is the most important target of the ground based interferometric detectors.

However, since the event rate is 10^{-5}～10^{-6} per year per matured galaxy as ours, we have to wait many years on average by the sensitivity to observe the VIRGO cluster (20Mpc). Because there is less than one galaxy per cubic Mpc.

Therefore, it is clear to everyone to develop more sensitive detector to see more remote galaxies. LCGT can see the event of nominal coalescence of BNS at 244Mpc.

View Ranges of Gravitational Wave Detectors



GW detection projects in the world

- TAMA Mitaka(NAO) 300m, 10W,FPMrec
- LIGO I Washington, Livingston 4km, 10W
- VIRGO France-Italy, Pisa, 3km
- GEO Germany England, Hannover, 600m
- Adv. LIGO USA
- EURO Europe
- AIGO Australia, WA, 3km
- LISA NASA-ESA Space mission 5Mkm
- DECIGO ‥‥

Characteristic of LCGT

- Based on TAMA (Sato's talk on Tuesday)
- 3km baseline PR-FPMI-RSE
- Cryogenics
  - 20K sapphire mirror (FP main)
- Underground
  - Stable & hard rock

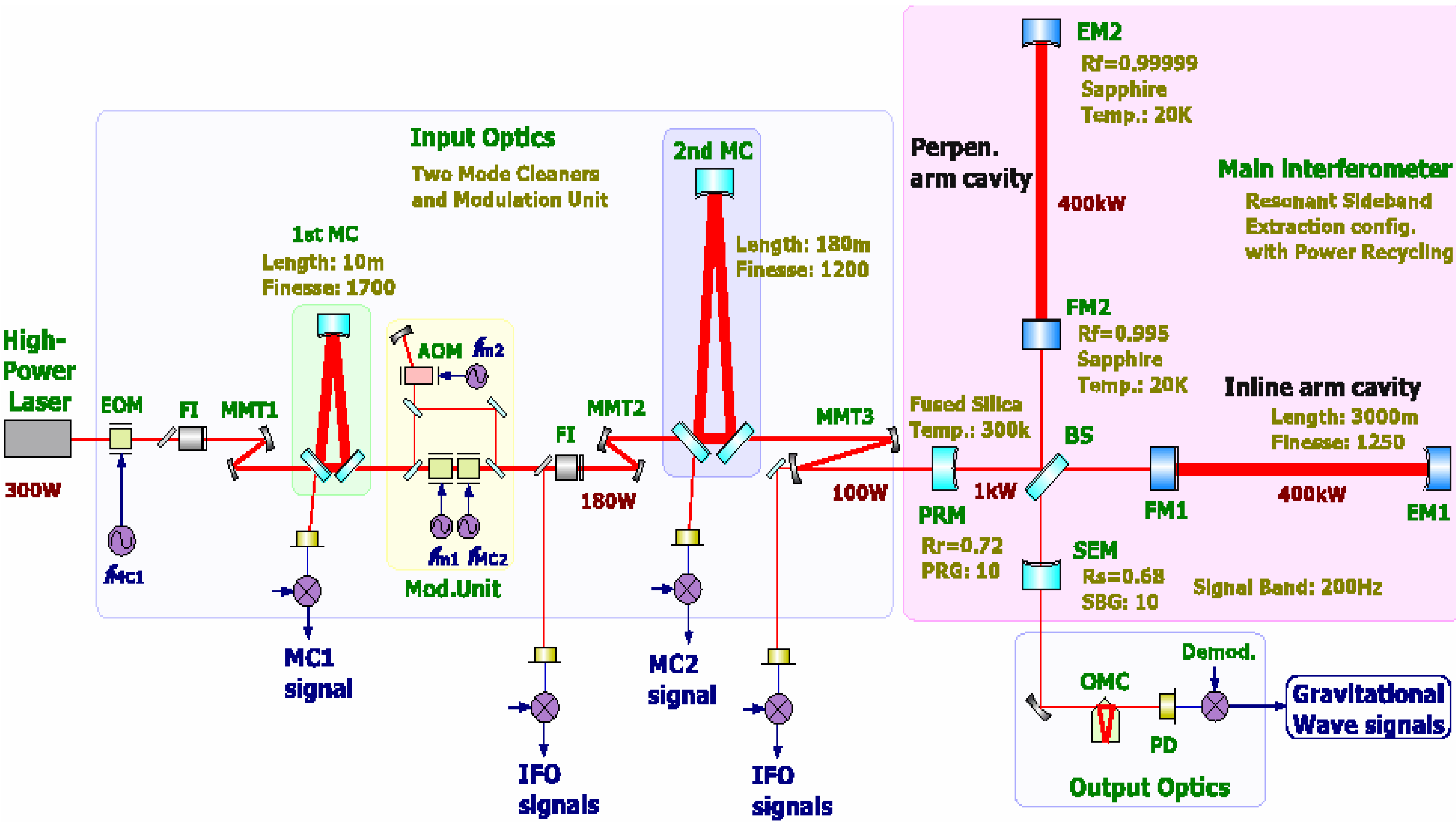
Features of Revised LCGT in 2003

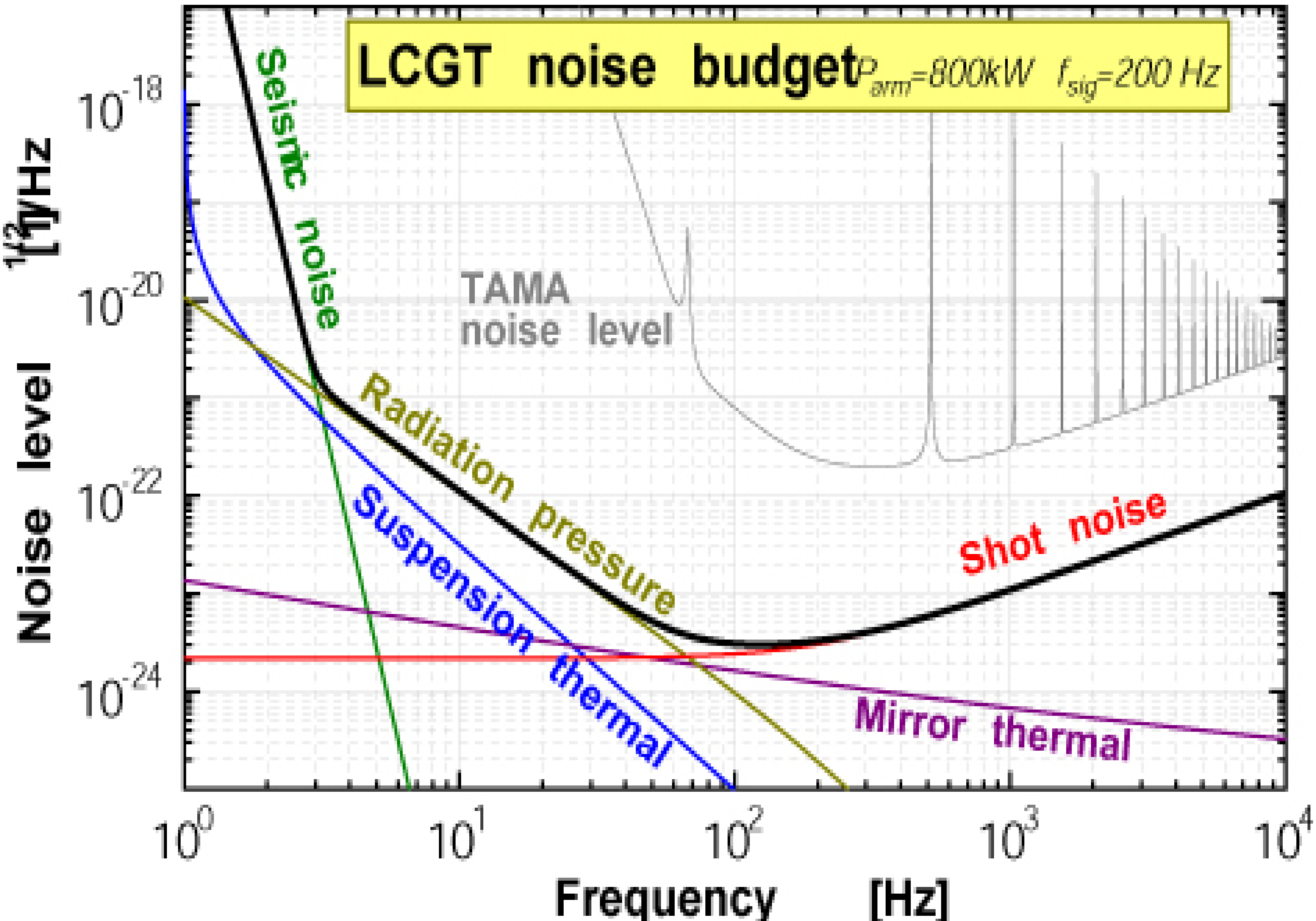
- Two parallel interferometers in the same tunnel with separate vacuum tubes
- Resonant Sideband Extraction
- Suspension Point Interferometer cutting vibration noises from refrigerators
- SAS at room temperature

Fake elimination using parallel Interferometers

- Assumption of the TAMA fake event << 1 / 1hour
- Coincidence analysis of two identical interferometer placed side by side
- Probability detecting noise within ±Δt is p^2 Δt
- Δt～0.5ms×3
- Expected rate of the signal event is assumed as 1event/year ->3×10^{-8} /s
- p^2 Δt < 0.27% × {3×10^{-8}}= 8×10^{-11} / s = 2.7×10^{-3} / year
- p< 2.3×10^{-4} = 1 / (1.2 hour)

An Optical Design of LCGT interferometer





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LCGT-site contour map in Kamioka

重力波観測施設用坑道平面図

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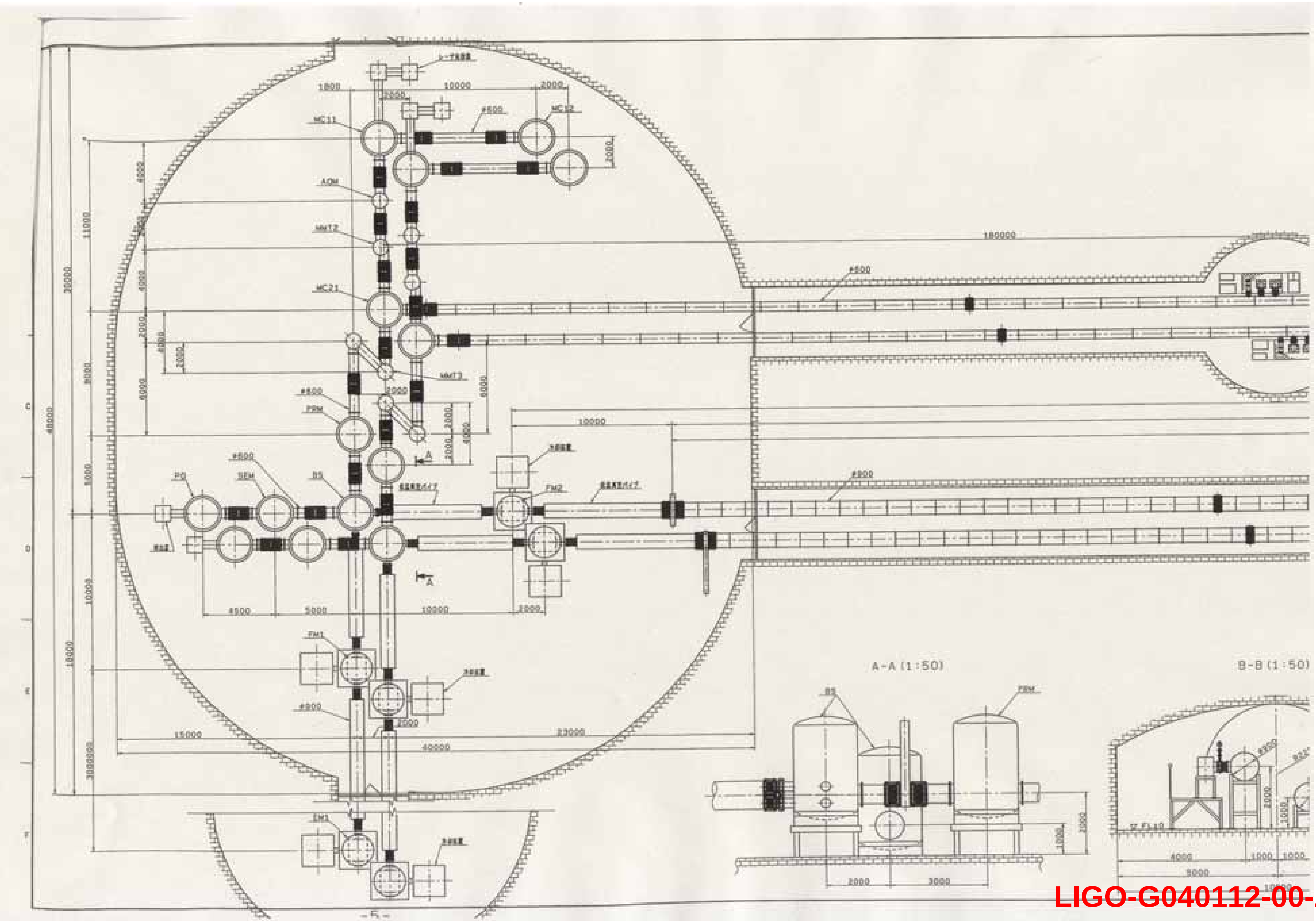
LCGT Vacuum design for cost-estimation (1)



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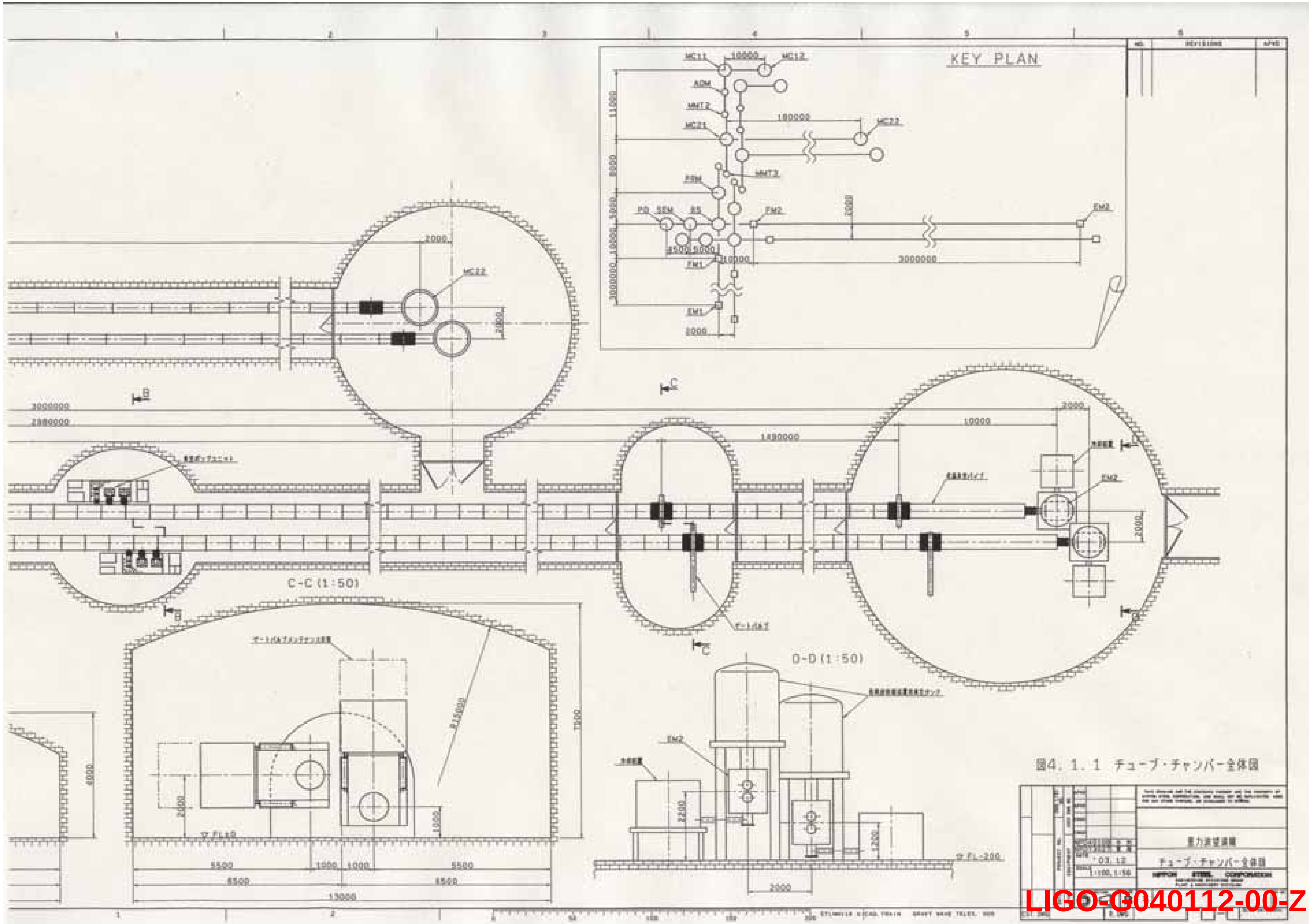
LCGT Vacuum design for cost-estimation (2)



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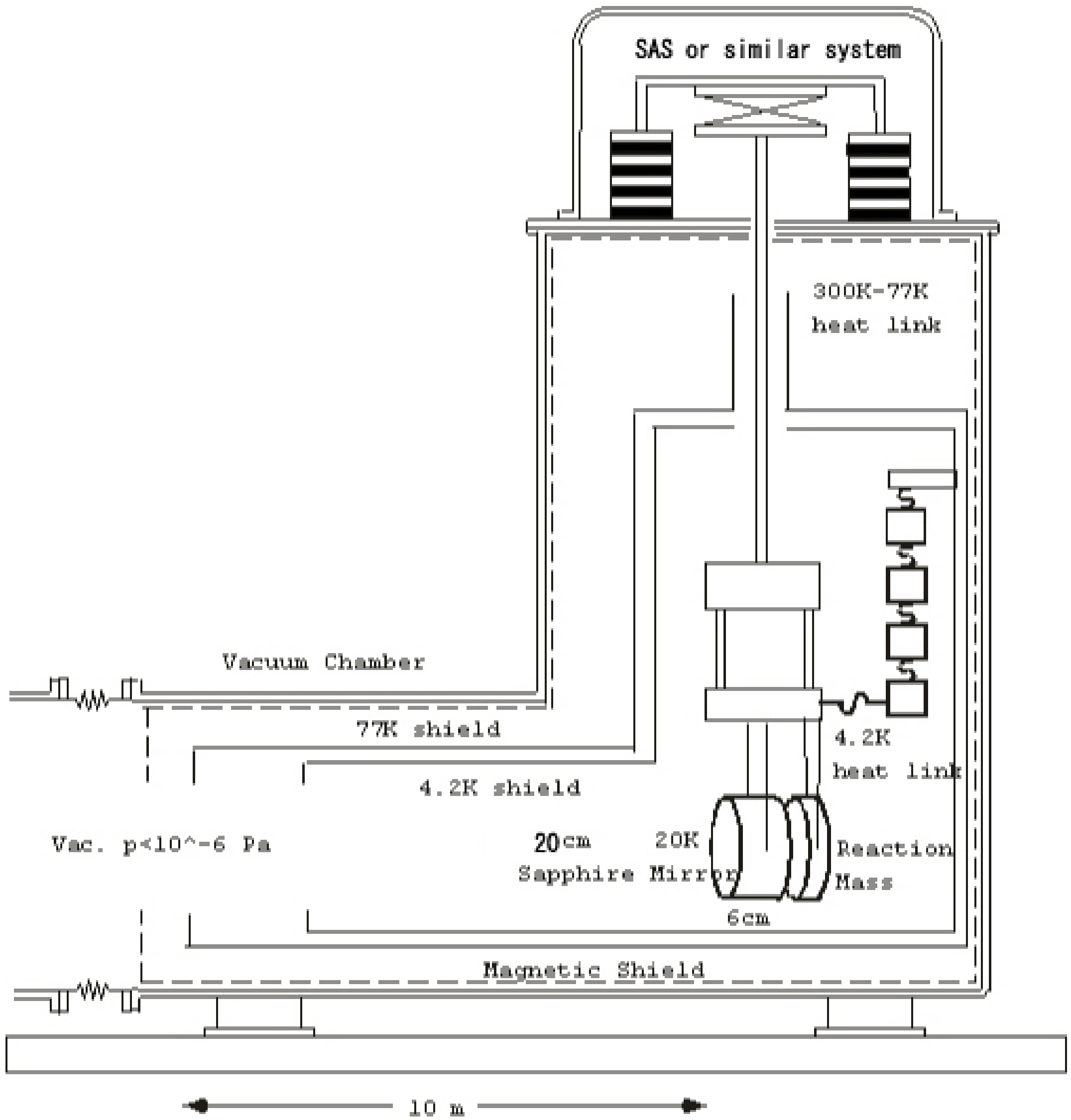


This is the original idea of cryogenic mirror and suspension.

The mirror is suspended by usual fibers and connected to the upper stage.

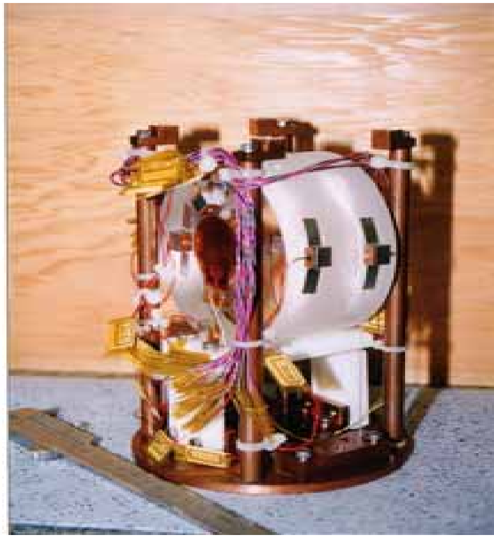
Whole part of the suspension is enclosed by double radiation shieldings.

The heat produced in the mirror is extracted from the upper stage by heat links.

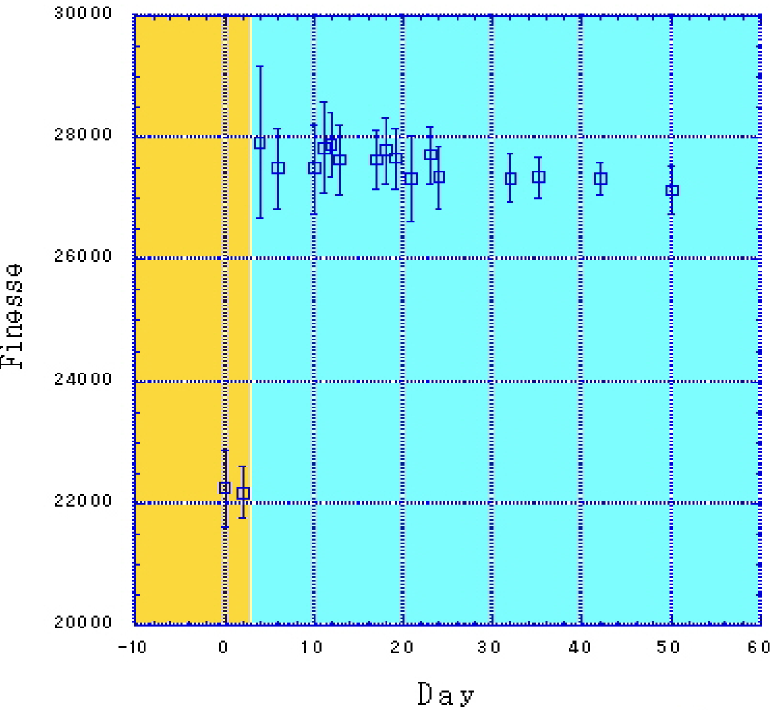
Those radiation shields extend to the beam tubes long enough to prevent heat coming into the mirror.

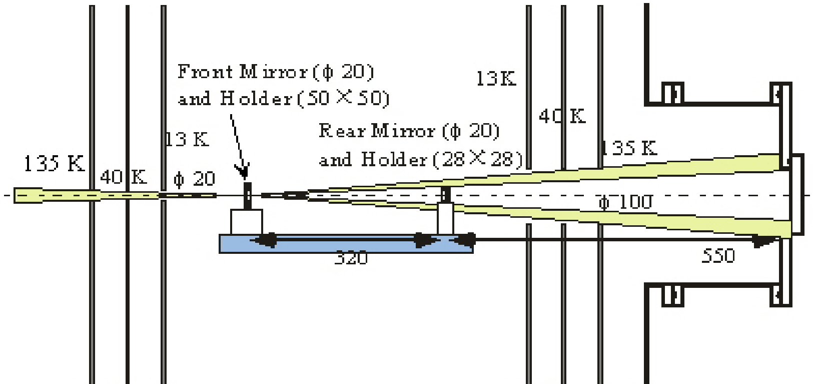
Summary of R&Ds of basic tests

Cooling test (Uchiyama et al., 1998)

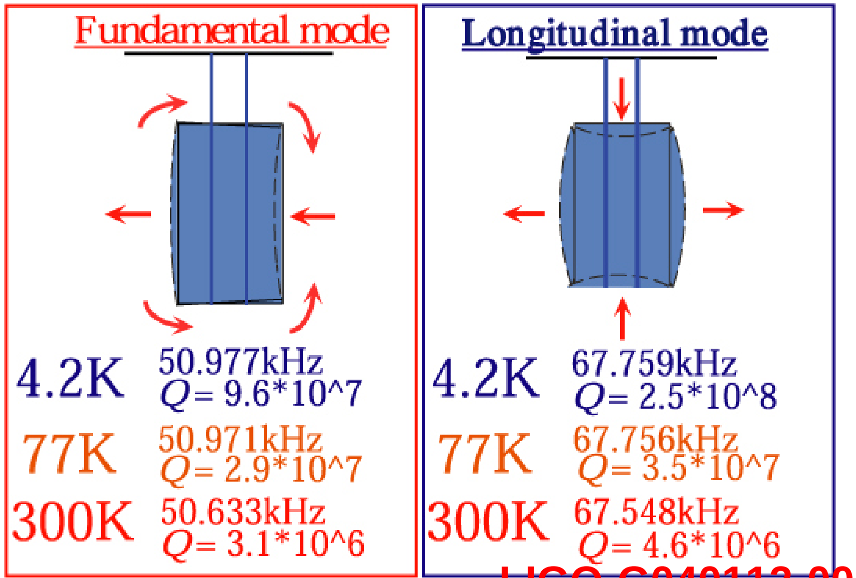


Contamination test (Miyoki et al., 2000)





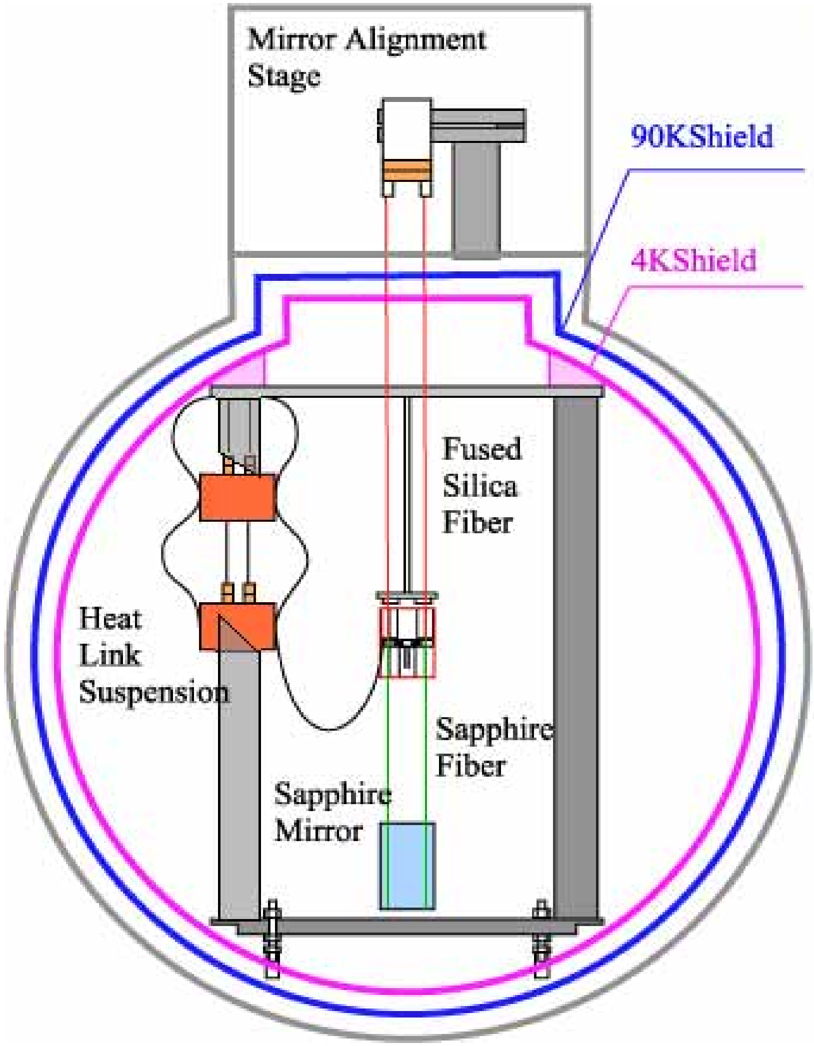
Mechanical Q test (Uchiyama et al., 1999)

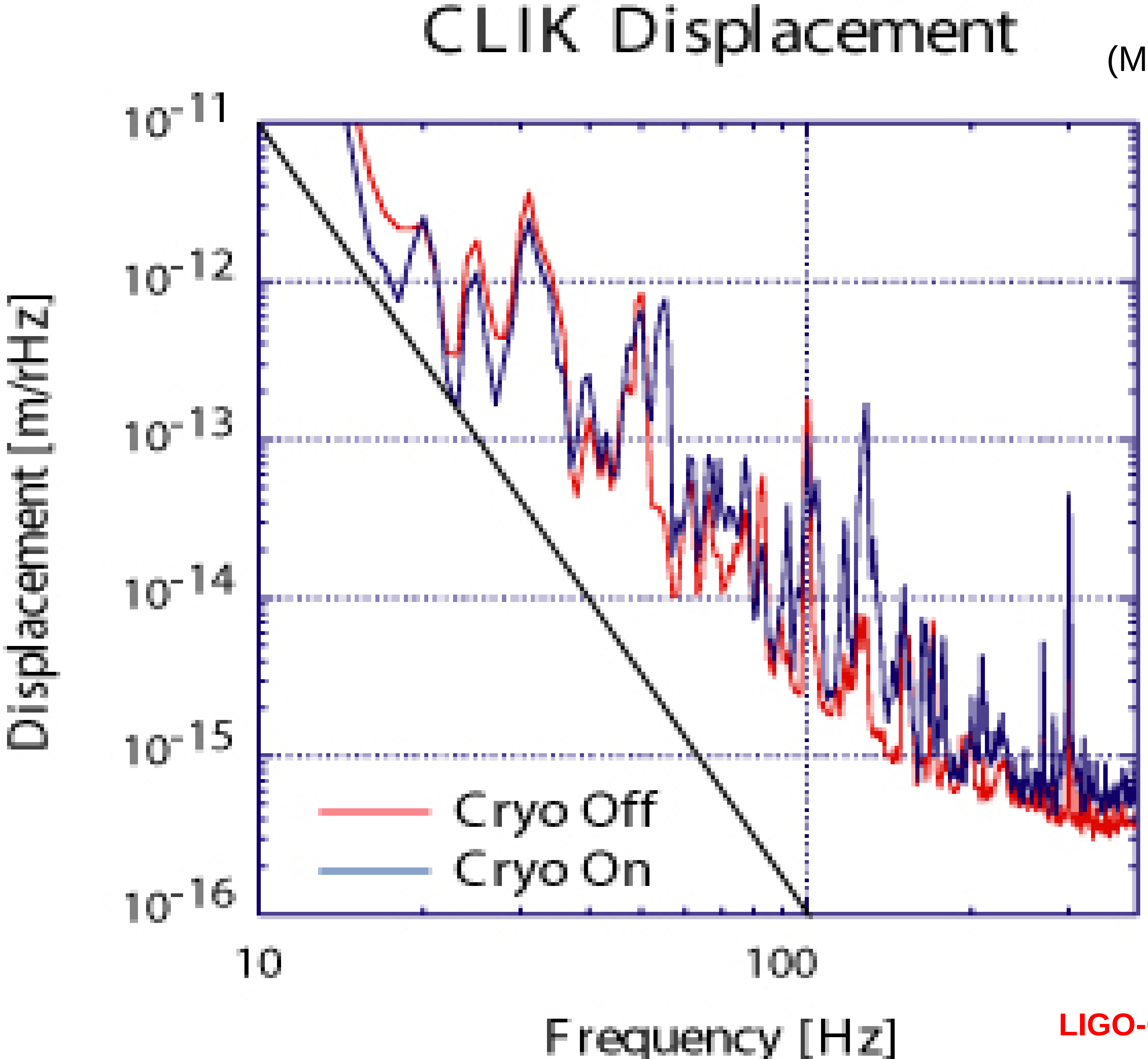


We got bonus of the reduction of thermo-elastic noise in cryogenic temperature (Uchiyama et al.) and low coating loss (Yamamoto et al.)

We had applied the result of these basic test to the 7 meter Fabry-Perot cavity cooled to less than 6 K at Kashiwa.

Suspension prototype was tested in Kashiwa campus in ICRR, in 2001.





(Miyoki et al.)

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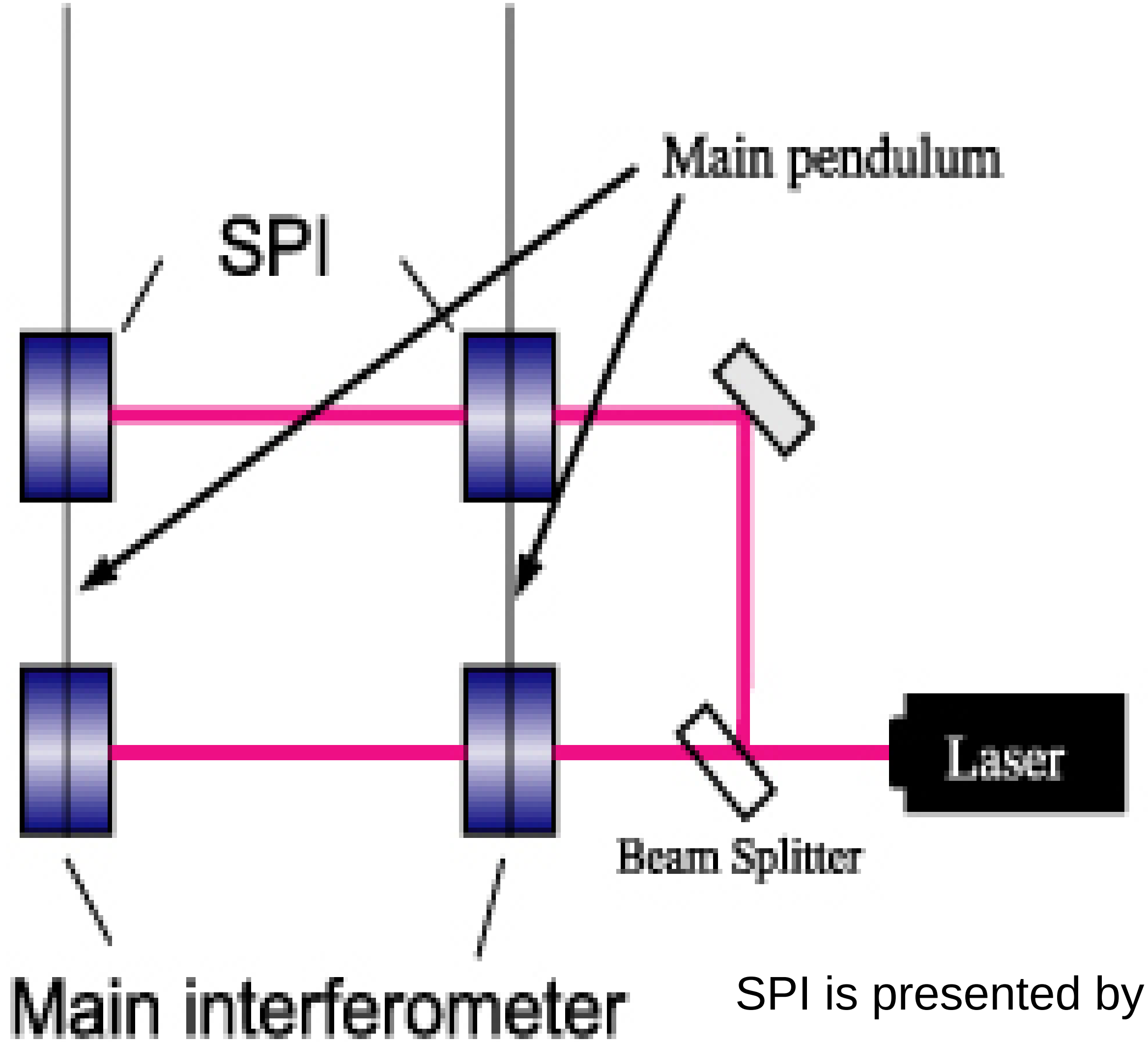
Suppose 30ppm/cm optical loss. Stored power in the MI-part is designed 1kW. It produces 540mW heat inside the near mirror (18cm long), if we take power recycling gain of 10 (1kW). As far as low power recycling gain is adopted, the heat production inside the near mirror is in tolerance. This is the reason why we need RSE. (Somiya gave a talk of RSE on Monday)

Test mass of LCGT is connected to a cooling system by a heat link that introduces mechanical noise. A suspension point interferometer (by Drever) is introduced to maintain high attenuation of seismic and mechanical noise without degrading high heat conductivity.

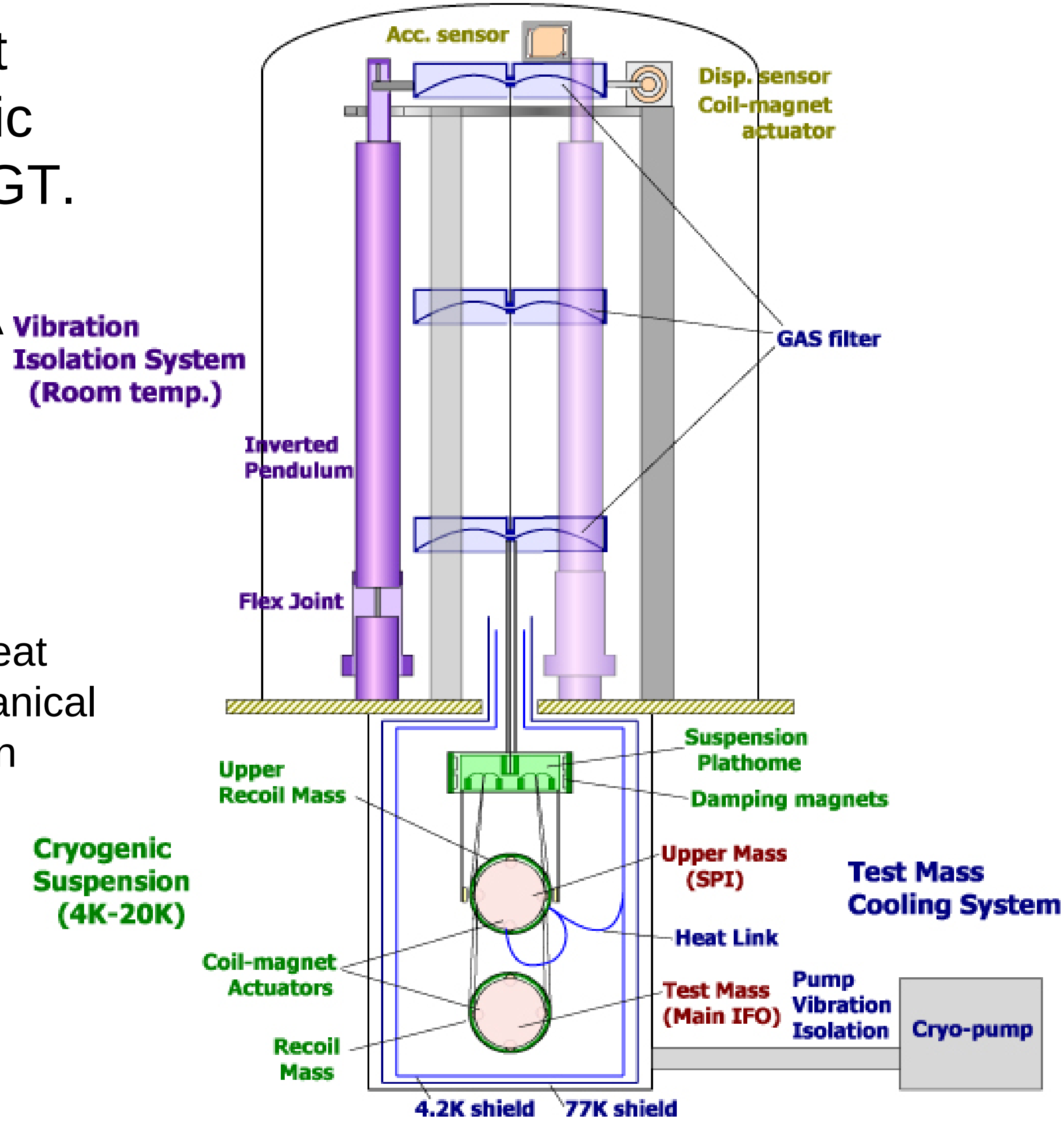


SPI is presented by Aso on Friday.

This is the present design of cryogenic suspension of LCGT.

SAS is installed to TAMA and tested. We expect more improved version will be feasible in LCGT. (Takamori, 2003)

Both conductivity of heat and isolation of mechanical vibration are needed in heat links. (Kasahara, 2003)



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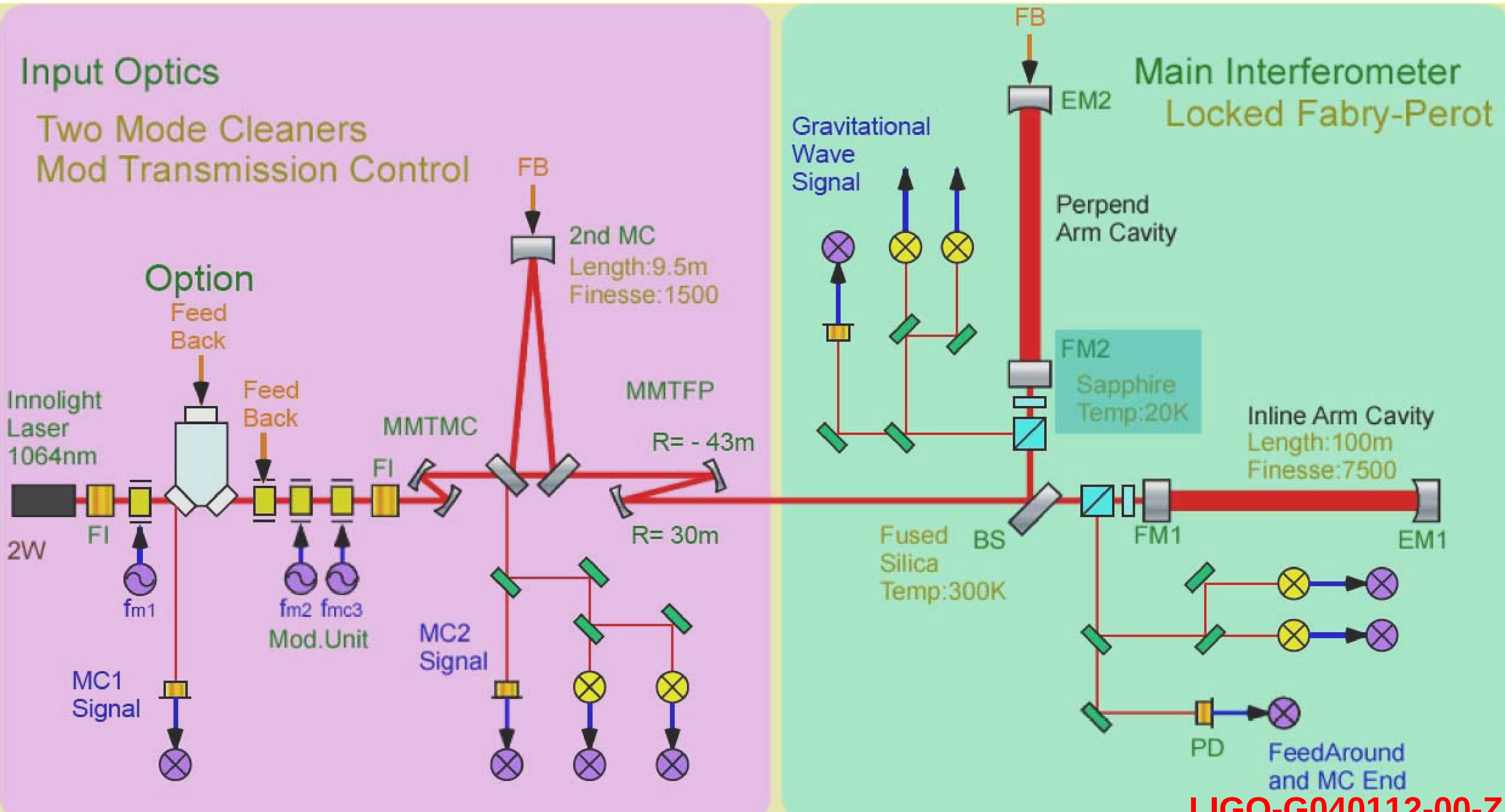
CLIO is a locked Fabry-Perot Interferometer



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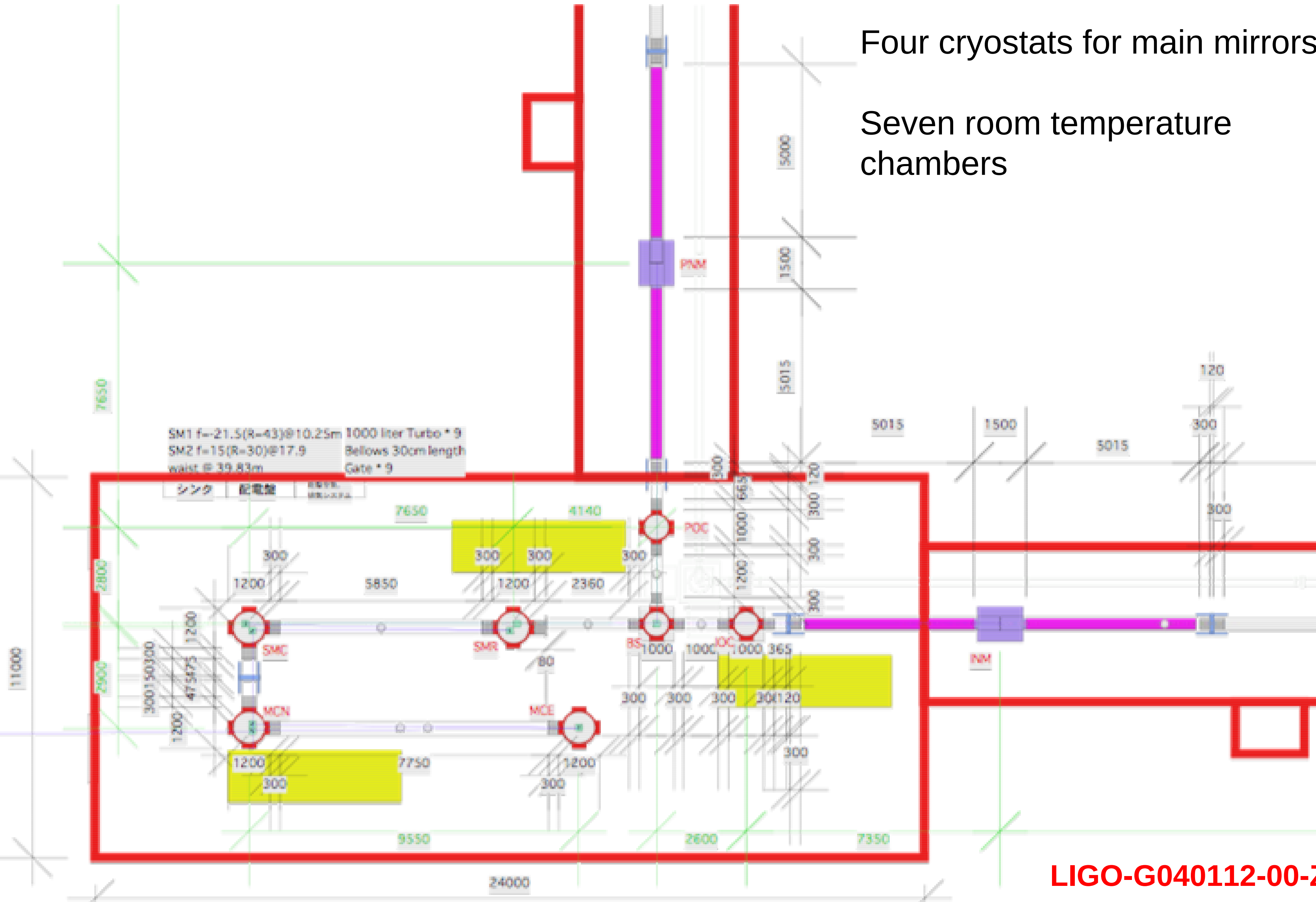
CLIO vacuum configuration

Four cryostats for main mirrors

Seven room temperature chambers



CLIO site in Kamioka mine in 2003

Geophysical strain meter is installed before CLIO construction (under)

Entrance (upper)

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CLIO construction

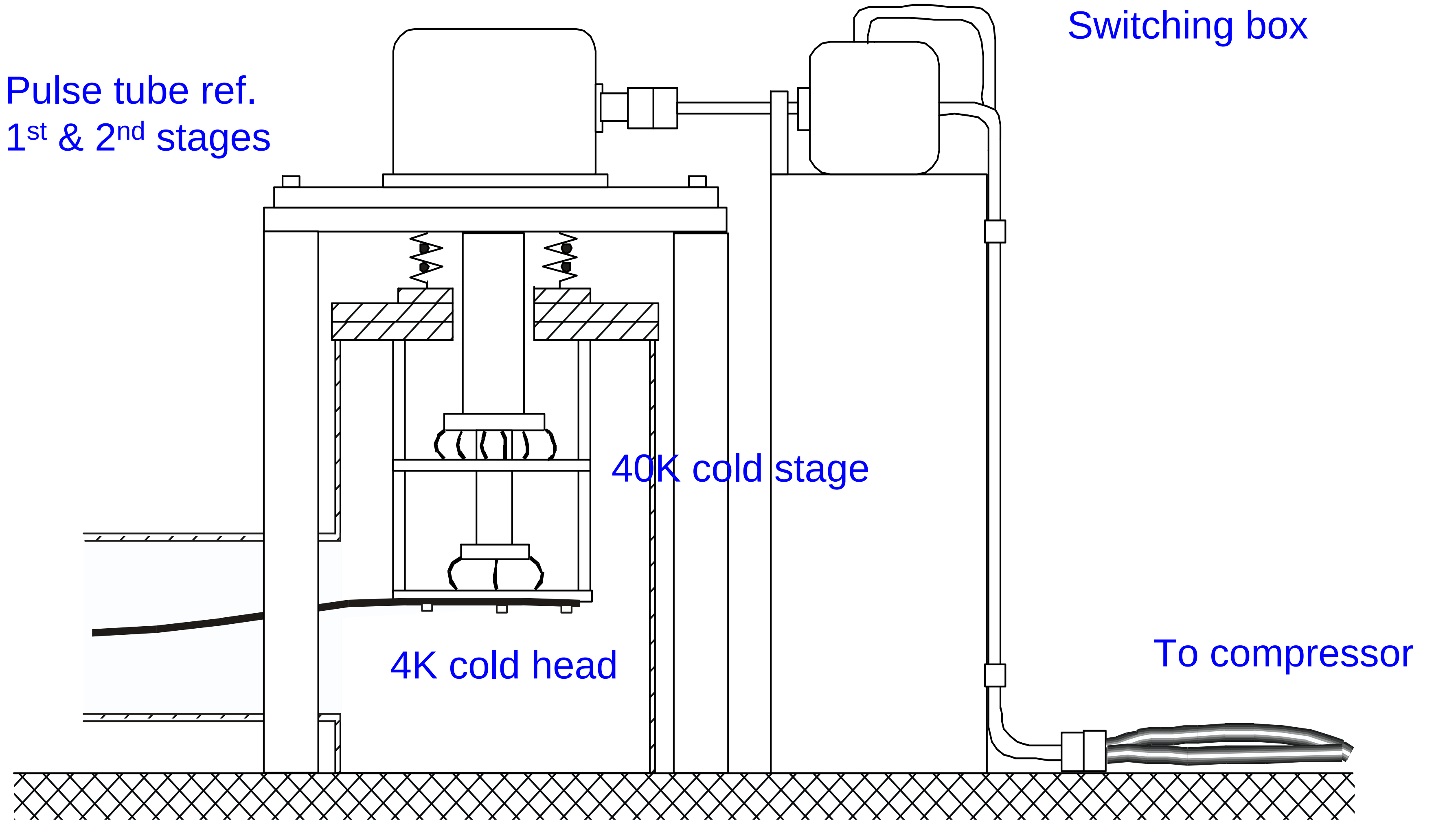
Mode cleaner vacuum chambers are installed with a connecting vacuum duct (left) in December, 2003.

Vacuum test has been finished (right)

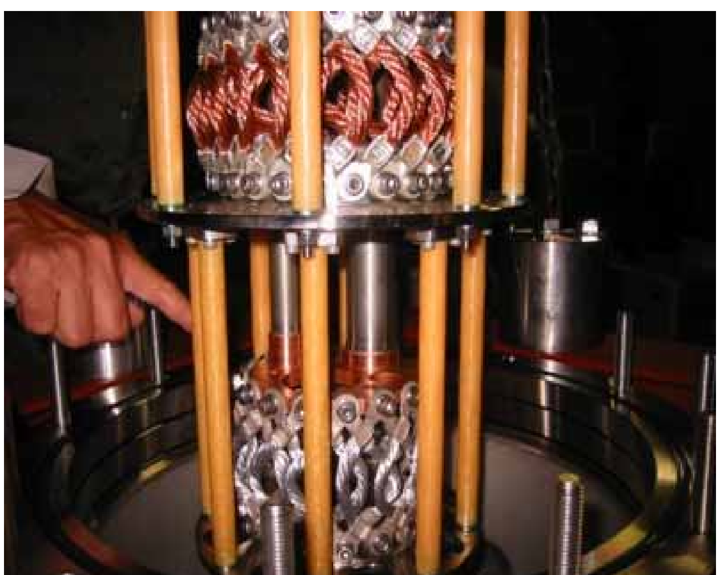
Schematic diagram of the refrigerator system (design in 2003)

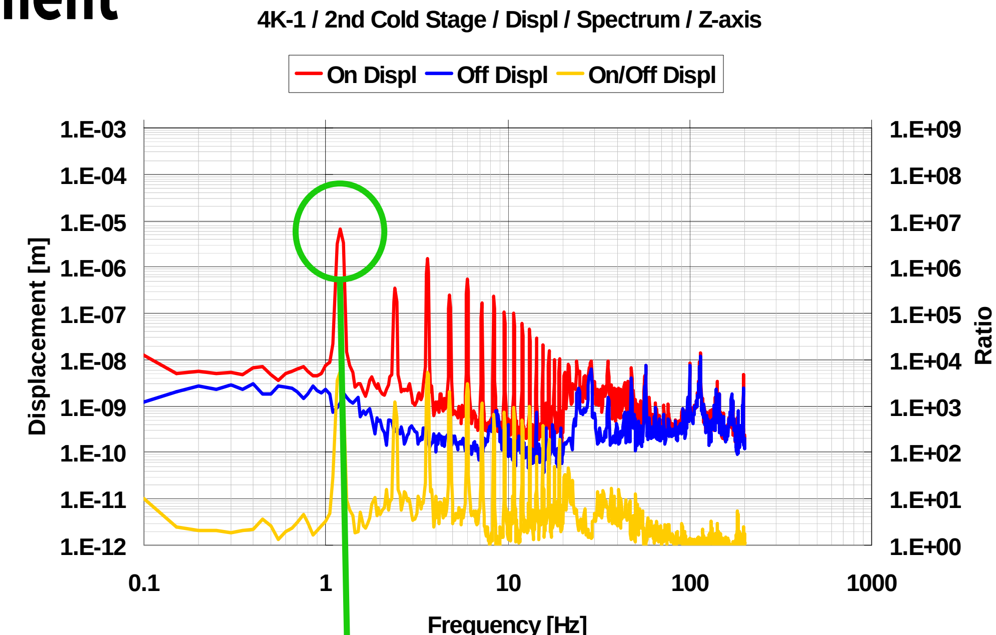
F-6: Class. Quantum Grav. (Accepted), Pr-1: Proc. 28th ICRC (2003),

patent: Pa-3 Tomaru et al., 2003; Suzuki et al., 2003.

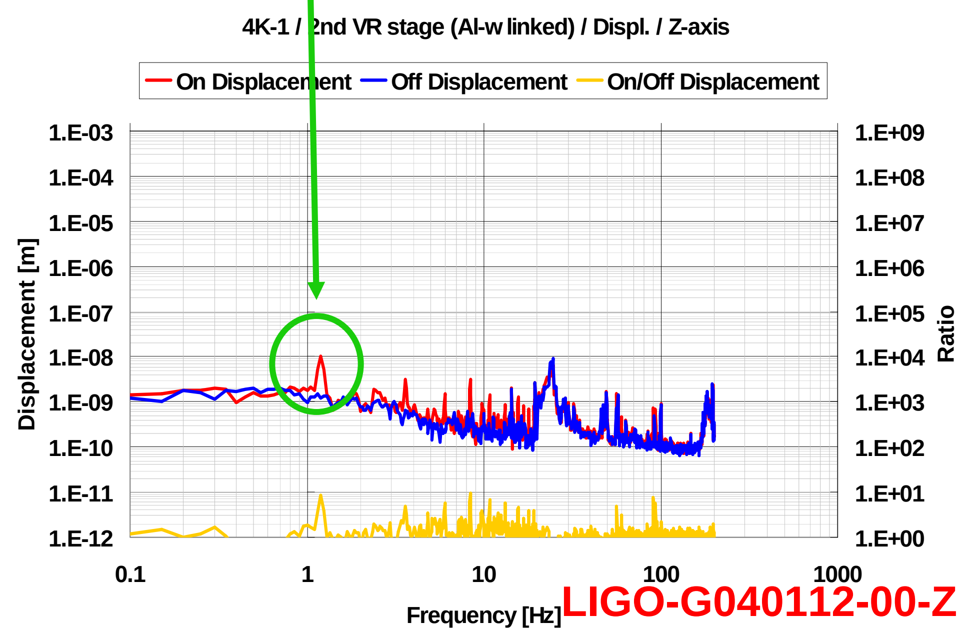


Cold Stage Vibration measurement





3 orders reduction



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LCGT Schedule

	1st year	2nd year	3rd year	4th year	5th year
Tunnel	*******	*******	*****fin		
Vaccu m		*******	*******	install	
Optics	**	**	**	*******	install
Electric				*******	***
Data					***

Estimated budget (in 2003)

- Tunnel Construction 3400 M JpnYen
- Vacuum system 12100
- Cryogenics 400
- Optics 800
- Suspension system 260
- Laser system 400
- Control system 100
- Computer 200
- Others 340

Total 18000

Summary

- Design in detail under revision
- Construction of CLIO for practical cryogenic interferometer
- Result of TAMA
  - Very close to the final sensitivity
  - Fulfillment of high stable operation in high disturbance of seismic noise
- Cost down negotiation with companies
- Budget asking to Government