

Status of LCGT

22 February 2000

Aspen Winter Conference on Gravitational Waves

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LCGT Collaboration

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Department of Physics, The University of Tokyo

Department Material Science, The University of Tokyo

ILS, The University of Electro-Communications

ERI, The University of Tokyo

Miyagi University of Education

Osaka University

Kyoto University

The University of Western Australia

Targets of LCGT

- Experimental detection of GW from NS-NS coalescence within 200Mpc
- Open a new window for Astronomy
- Develop a new horizon of high energy physics beyond an energy frontier of particle accelerator

Foundations of LCGT

- Take over the products of TAMA300
 - Injection locked Nd:YAG laser
 - Ultra-low loss mirror coating
 - Double pendulum suspension
 - Non-baking ultra-high vacuum system
 - X-pendulum vibration isolator
- Cryogenics for suppressing thermal noise
 - Reduce the thermal force by smaller T and higher Q
 - Sapphire mirror + sapphire fiber
- Select a quiet site : Kamioka mine
 - Decrease the source of seismic vibration
 - Stable environmental temperature

Cool down a mirror

- Heat generation on the mirror
 - ✦ irradiated by high power laser
 - ✦ finite absorption of mirror substrate and coating
- High-Q mirror suspension

Solution

- Sapphire fiber suspension
 - ✦ large thermal conductivity (~ 200 W/cm/K @ 20K)
 - ✦ high-Q at cryogenic temperature

(Phys. Lett. A242 (1998) 211 - 214.)

Q-factor measurement of Sapphire cylinder

Practical configuration

Sapphire cylinder 100mm x 60 mm

c-axis // cylinder axis

Suspension: 2 loops of sapphire fibres (250 mm)

Ring down method

exciter: PZT oscillator on a flap

transducer: dc-biased capacitance

thin Al coated on an end surface

(Phys. Lett. A261 (1999) 5.)

Q-factor measurement of sapphire fiber

Sapphire fibre : 250mm

Bending vibration : clamped - free

frequency : 200Hz - 500Hz varying with length

Temperature : 300K - 6K

Ring down method

excitation : small hammer

motion pickup : shadow sensor

$Q = 1 \times 10^7$ at $\omega = 200 \text{ Hz}$, $T = 6 \text{ K}$

(Publish in preparation)

Contamination problem

Molecular flux from 300K to cryogenic surface

Cryogenic mirror -> cryopump ?

Experimental evaluation

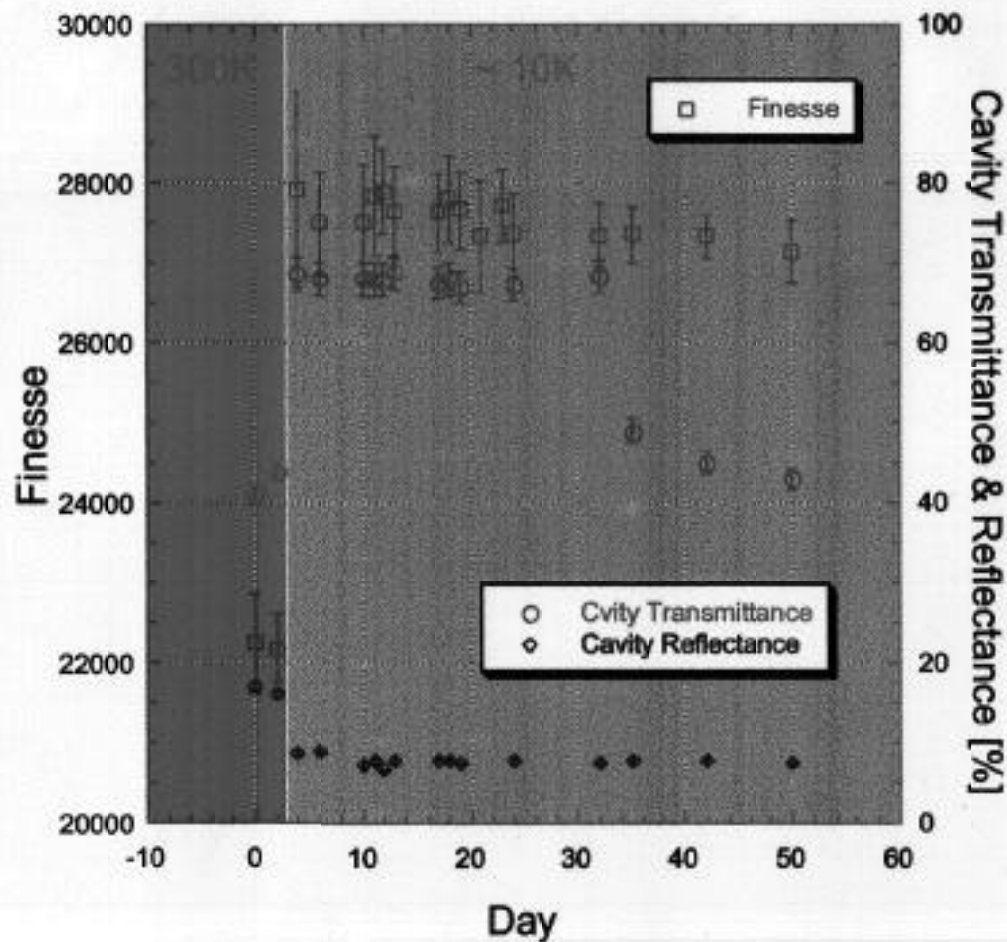
Finesse measurement of a cryogenic F-P cavity

Reversible or irreversible ?

Experiment 1 Cryogenic FP with coupling hole
(to be published in *Cryogenics*)

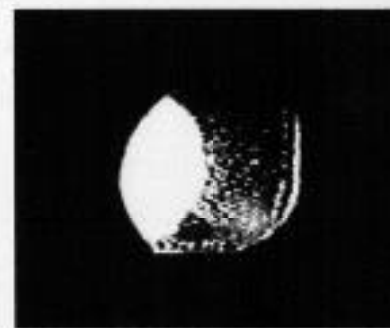
Experiment 2 300K mirror + cryogenic mirror -> FP

Experiment 2 Finesse, Cavity Reflectance and Transmittance Change



◆ Contamination rate for the reflectance --- 0.12ppm/day

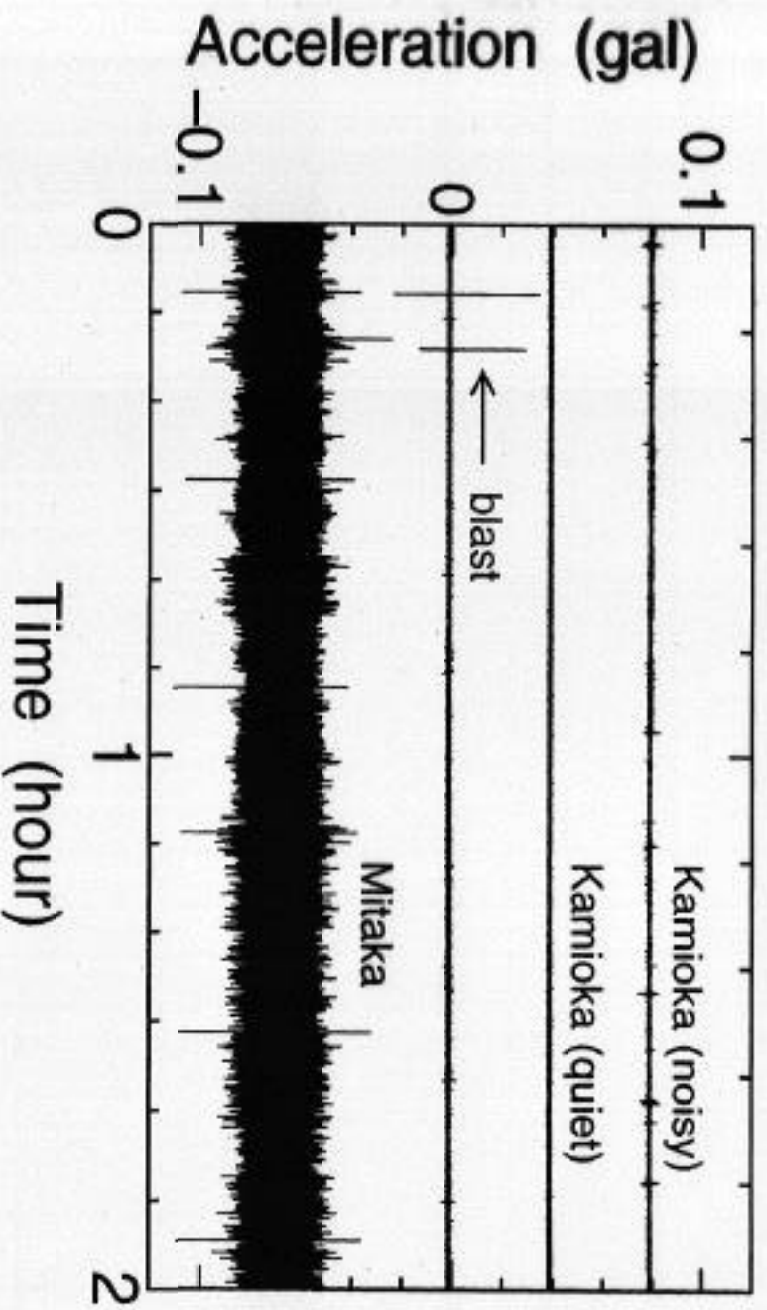
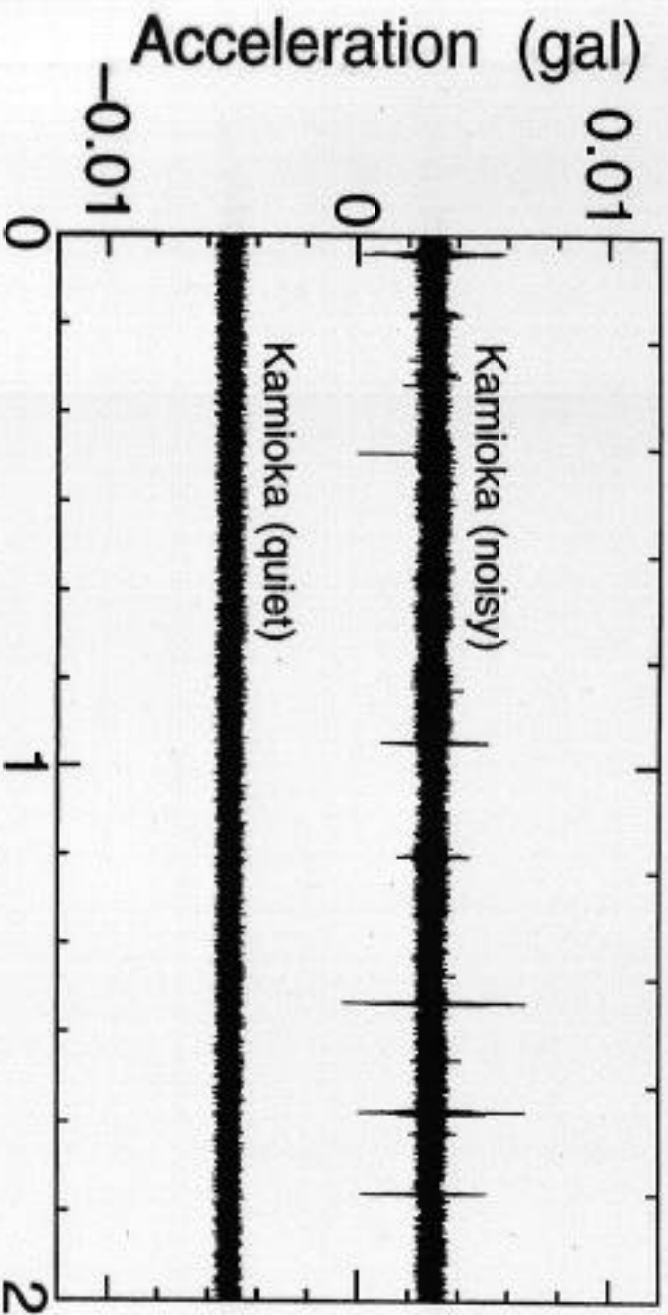
◆ Ice on the AR surface of the output mirror due to accidental leak.



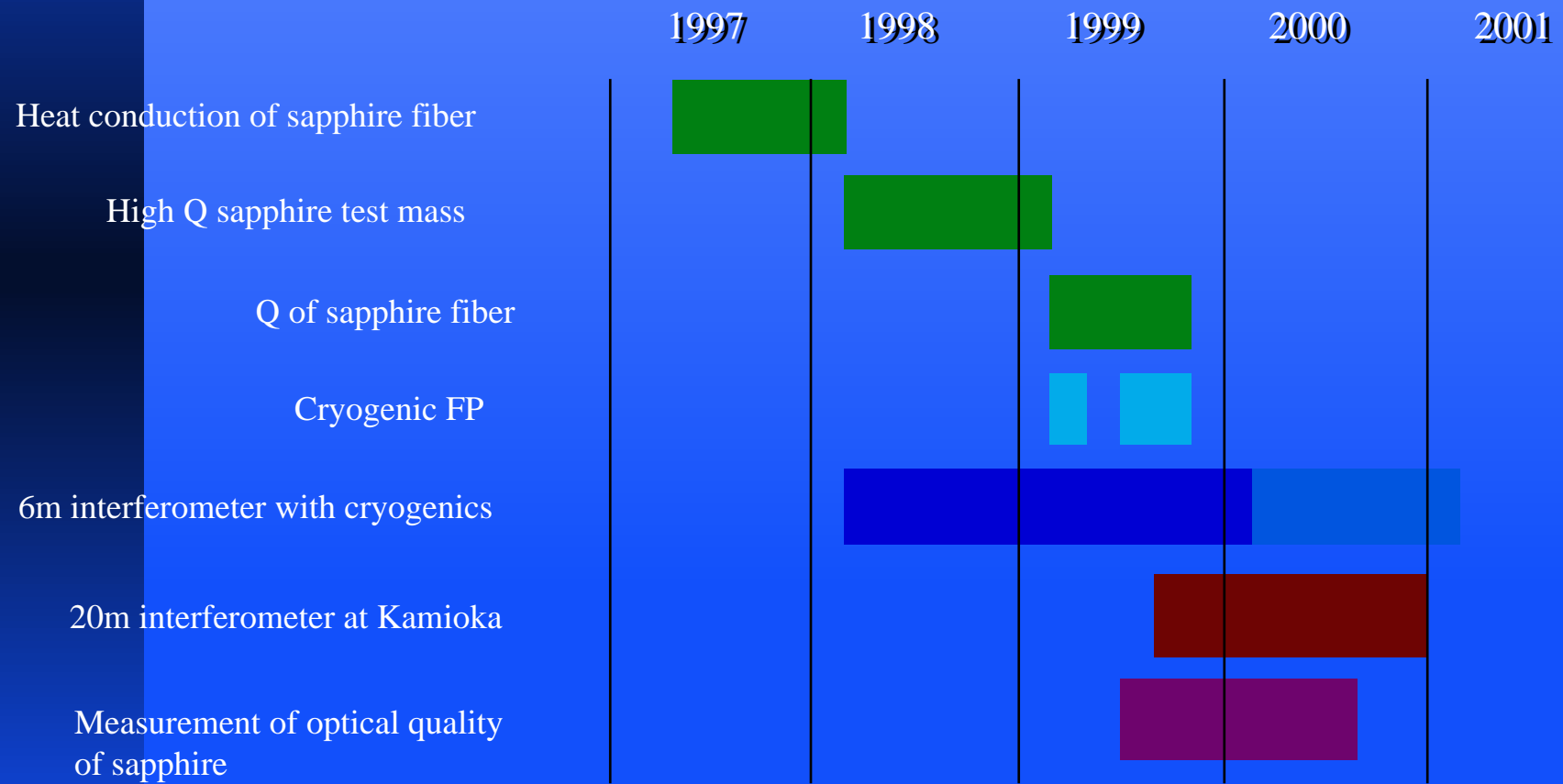
Material was estimated by monitoring its vaporization temperature and the equilibrium pressure level.

Kamioka mine

- Location : about the center of main island Japan
 - Longitude ~E 136.5 deg. , Latitude ~N 36.5 deg.
 - approximately 60 km from the sea
- stable temperature in the tunnel
- 1000 m overlying mountains
 - Rock type Amphibolite and gneiss
 - Density 2600 kg/m³
 - Comp. Strength 149 MPa
 - Tensile Strength 9.7 MPa
 - Young's modulus 49.9 GPa
 - Elas. Wave velocity 4930 m/sec
- smaller seismic motion



R & D milestones



R&D Issuers

- 6m interferometer
 - refrigerator vibration
 - heat link + vibration isolation
 - practical operation
- Actuator in cryogenic environment
- Low frequency anti-vibration system
 - active isolator
 - X-pendulum
- 20m interferometer
 - Long term stable operation in Kamioka
- High power laser
 - light amplification
- Development of sapphire mirror
 - 300K fabrication -> cryogenic operation

Schedule

- FY. 2000 Design Review
- FY. 2001 Budget Demand
- FY. 2002 Start Construction