Development of the accelerometer for cryogenic experiments II

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0. Abstract

Current status of the development of the accelerometer

for cryogenic experiments (LCGT and CLIO project)

Contents

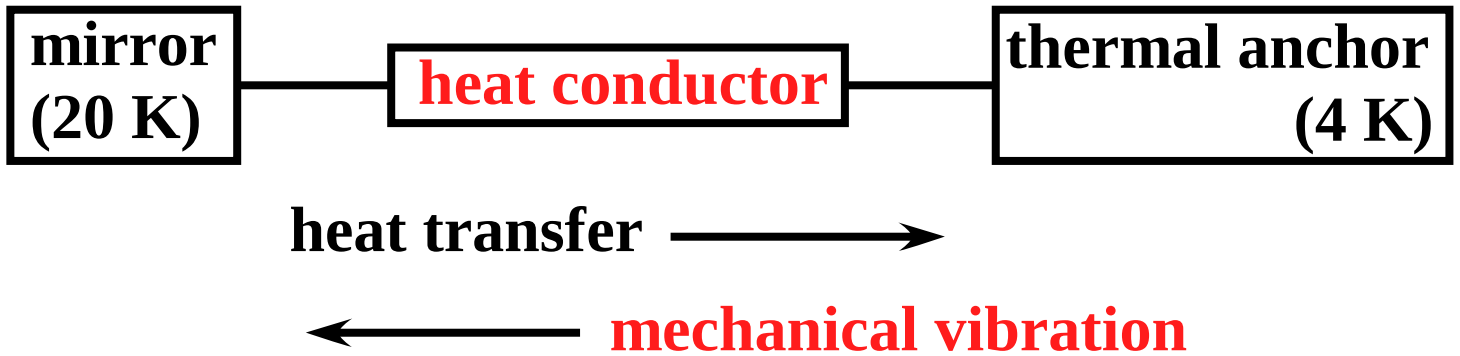
1. Introduction

LCGT and CLIO : future and current Japanese project

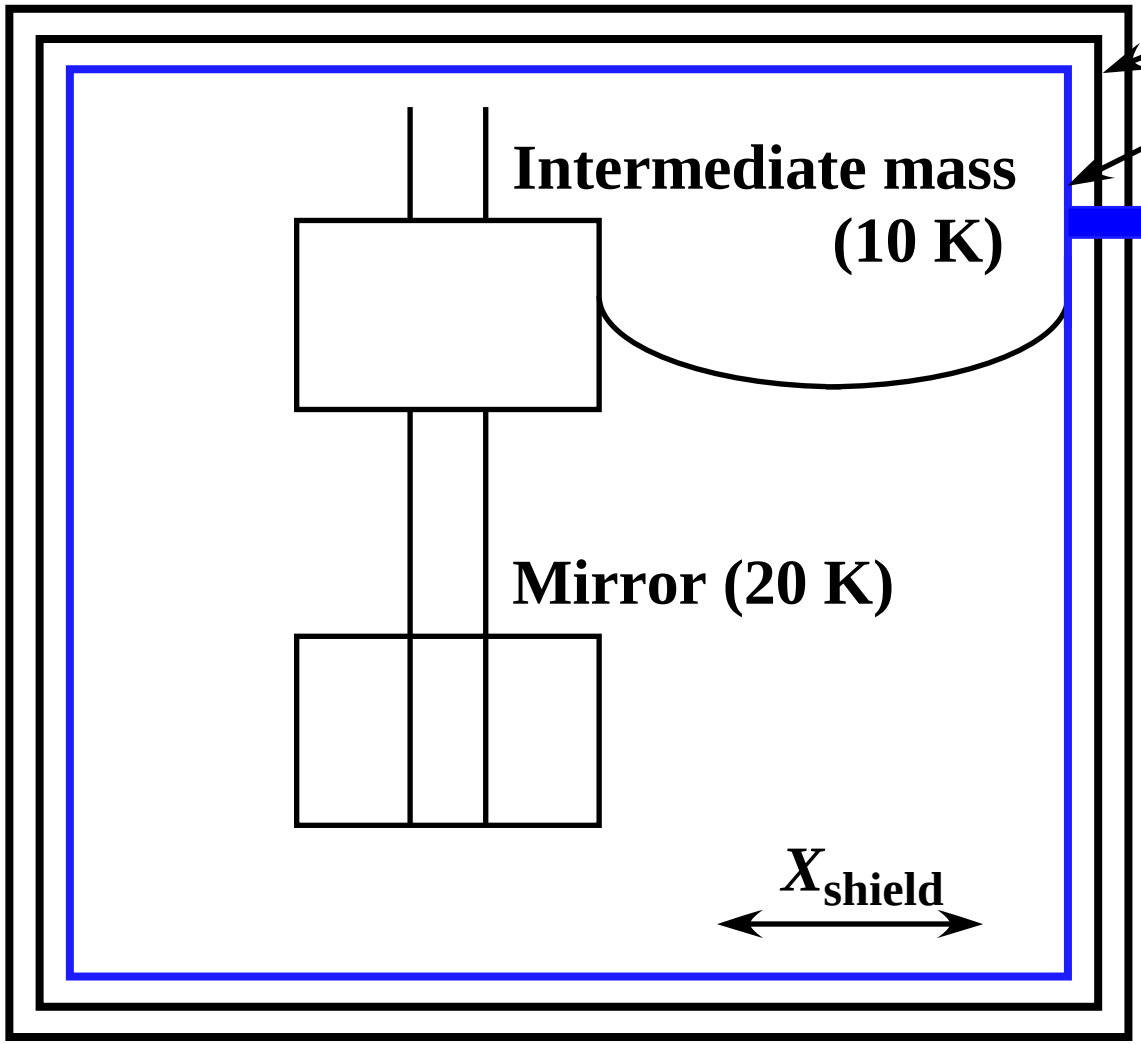
to construct the interferometric gravitational wave detector

Cryogenic interferometer (20 K) : reduction of thermal noise

Heat absorption in the mirrors : about 1 W in LCGT



Schematic view of cryogenic apparatus



Vibration isolation for shield is difficult !

Resonant frequencies of shield : 10 Hz - 100 Hz

$$X_{shield} > X_{seismic}$$

Measurement is necessary.

Accelerometer at low temperature

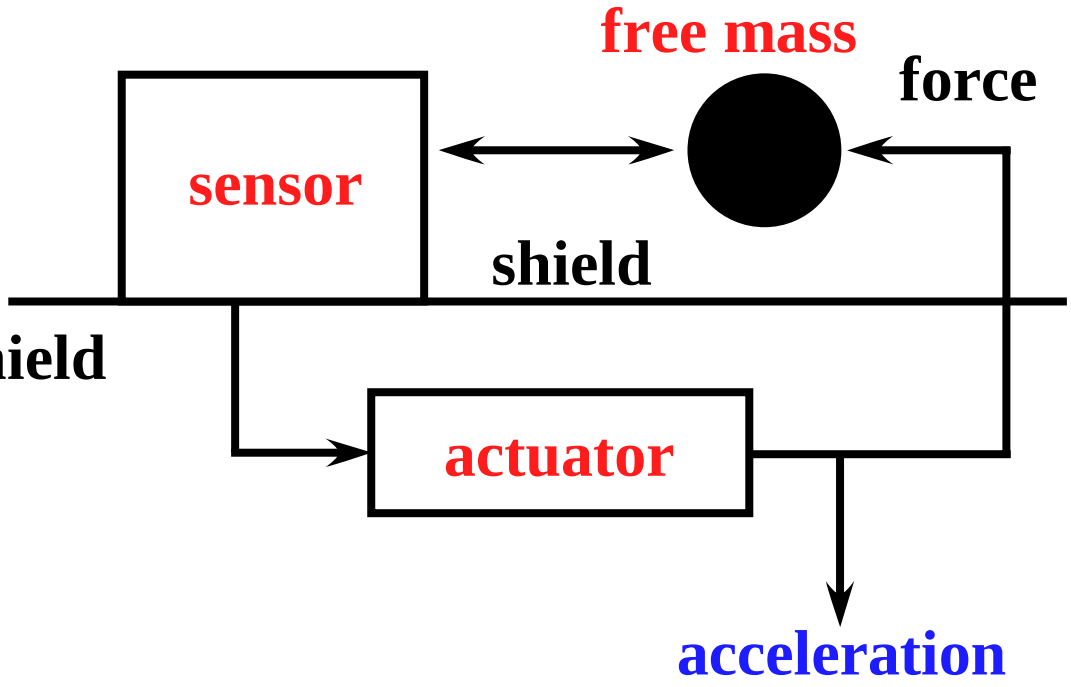
2. Outline of Experiment

2-1. Outline of accelerometer

(i) free mass : reference

(ii) sensor : displacement between free mass and shield

(iii) actuator : feedback



Mass follows shield.

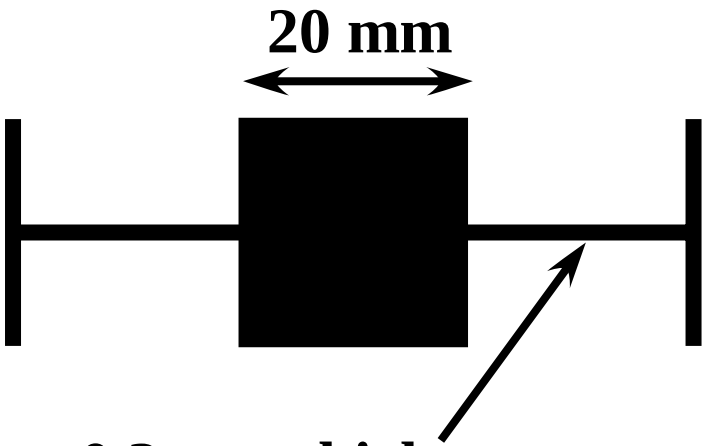
→ Acceleration of shield is derived from feedback signal.

Horizontal and vertical vibration measurement

→ Only horizontal vibration in this talk

2-2. Components of accelerometer

(i) free mass : mechanical harmonic oscillator



material : phosphor bronze

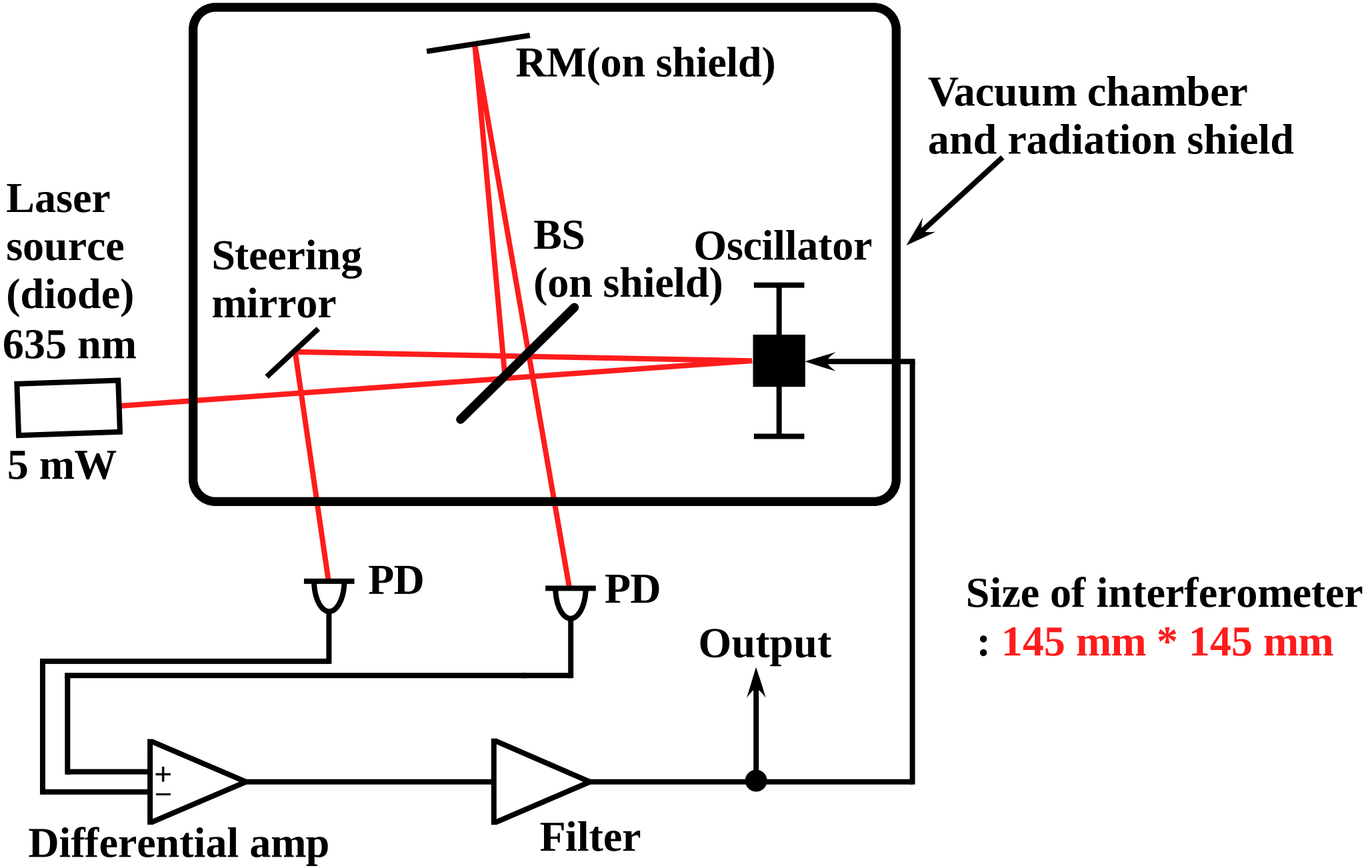
resonant frequency : 20 Hz

0.3 mm thickness
2 mm width

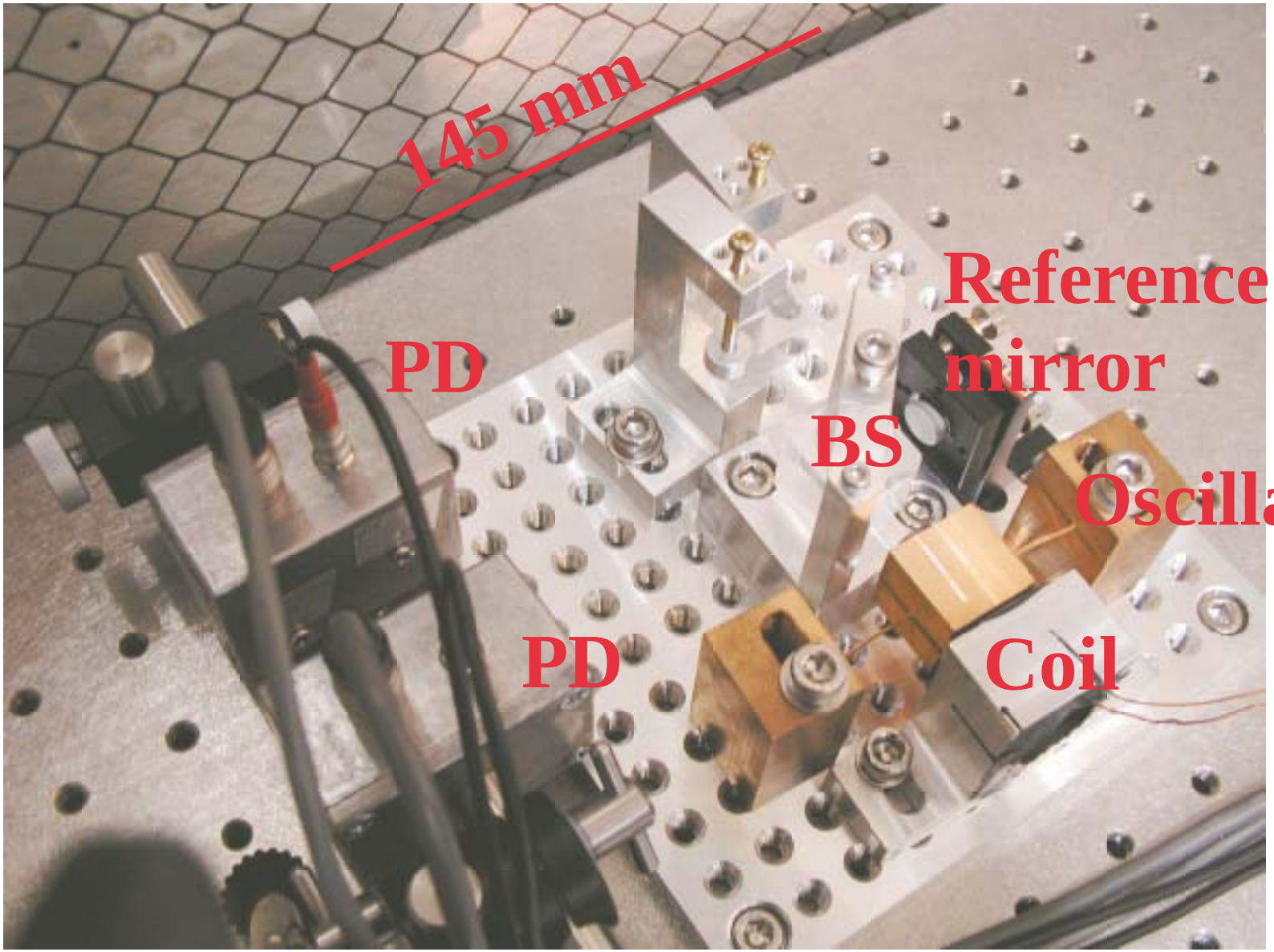
(ii) sensor : Michelson interferometer
(calibration)

(iii) actuator : coil-magnet actuator
(operation at low temperature)

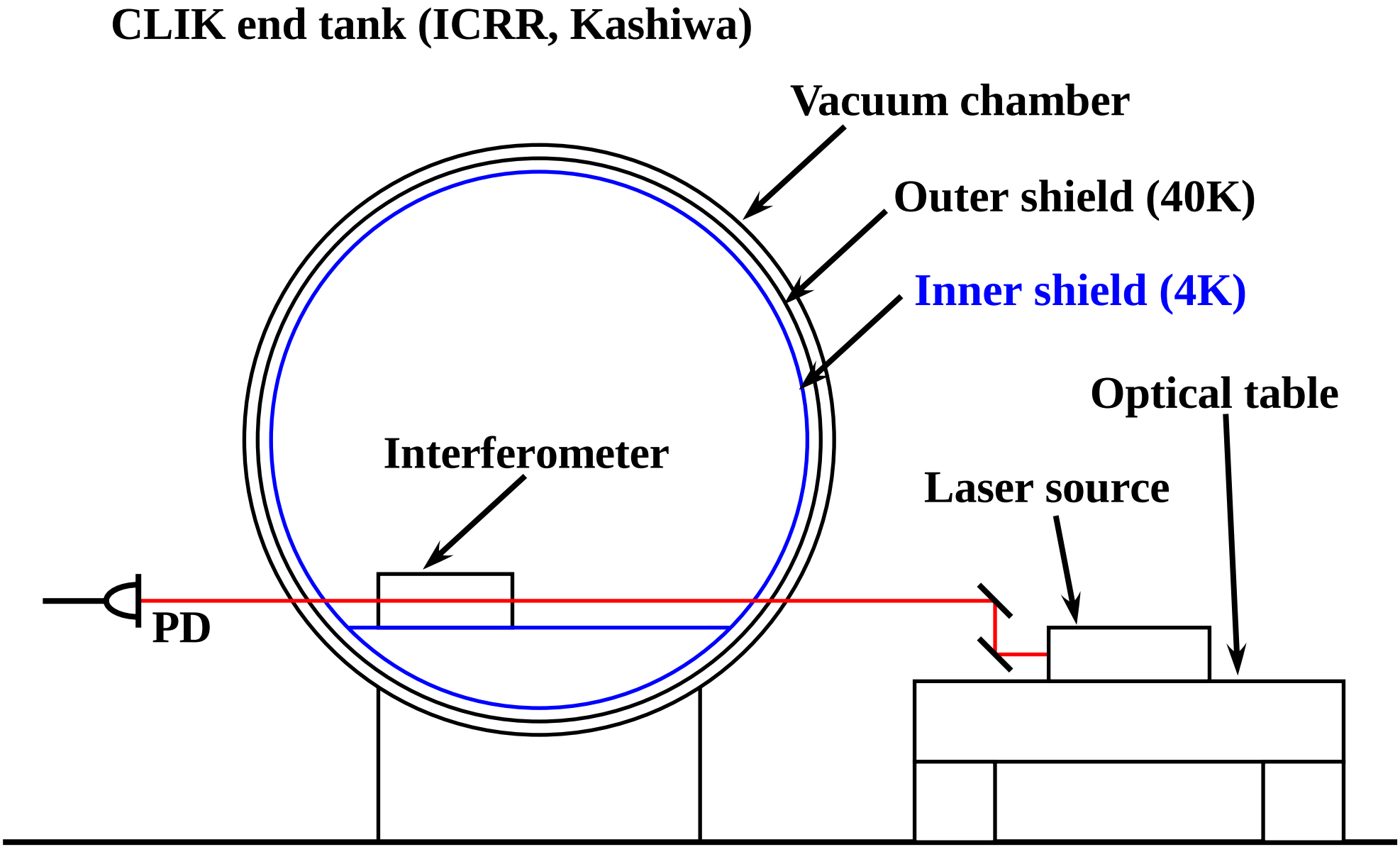
2-3. Schematic view of accelerometer



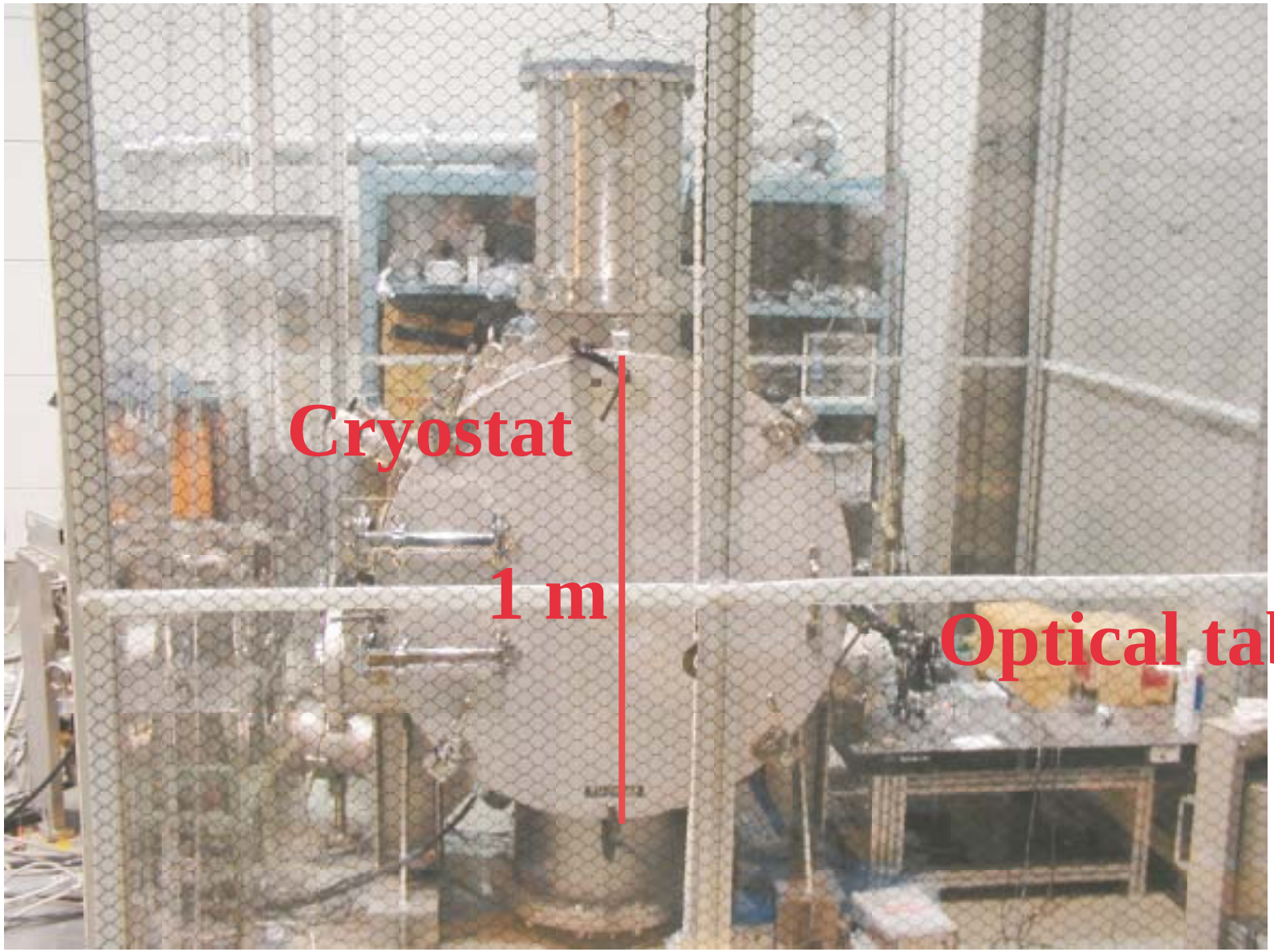
Interferometer



2-4. Schematic view of cryostat



Cryostat (CLIK end tank)



2-5. Refrigerator and vacuum pump

(i) Refrigerator of CLIK : 4 K 2 stage Gifford-McMahon

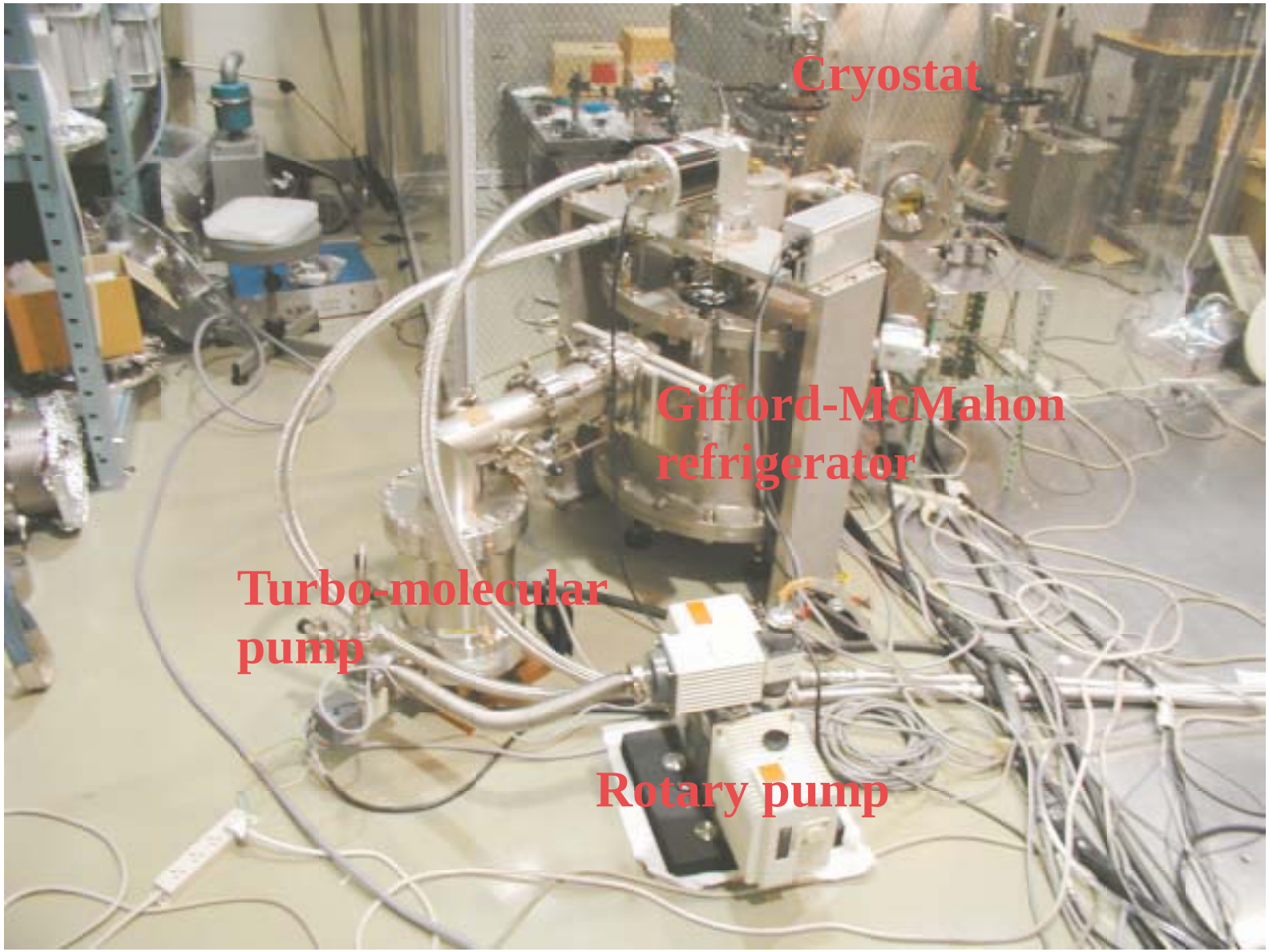
Large vibration

Refrigerator of CLIO : 4 K 2 stage Pulse-tube

Small vibration (Talk of T. Suzuki)

(ii) Vacuum pump : Rotary pump and Turbo-molecular pump

Refrigerator and vacuum pump



3. Results

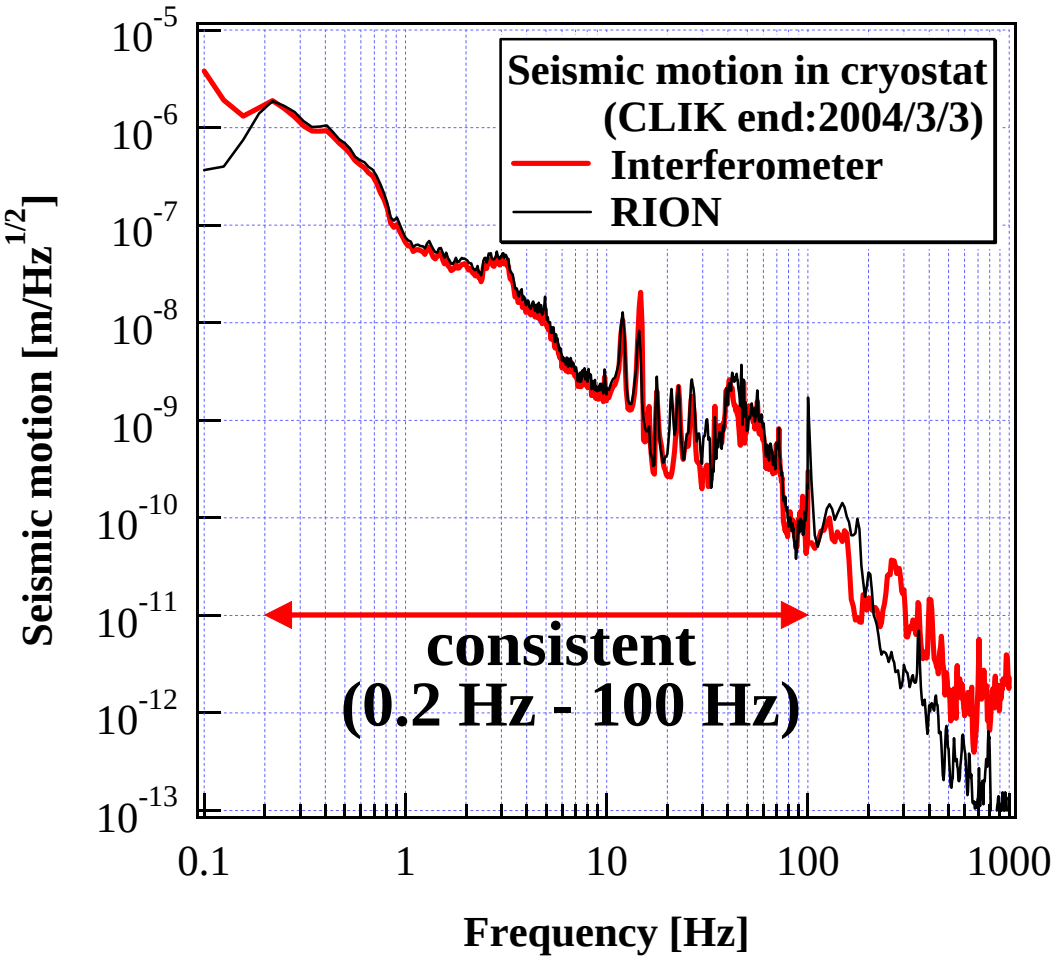
3-1. Operation at room temperature (1)
(Operation check)

Comparison

with RION

accelerometer

in air



3-2. Operation at room temperature (2)
(Cryostat vs optical table)

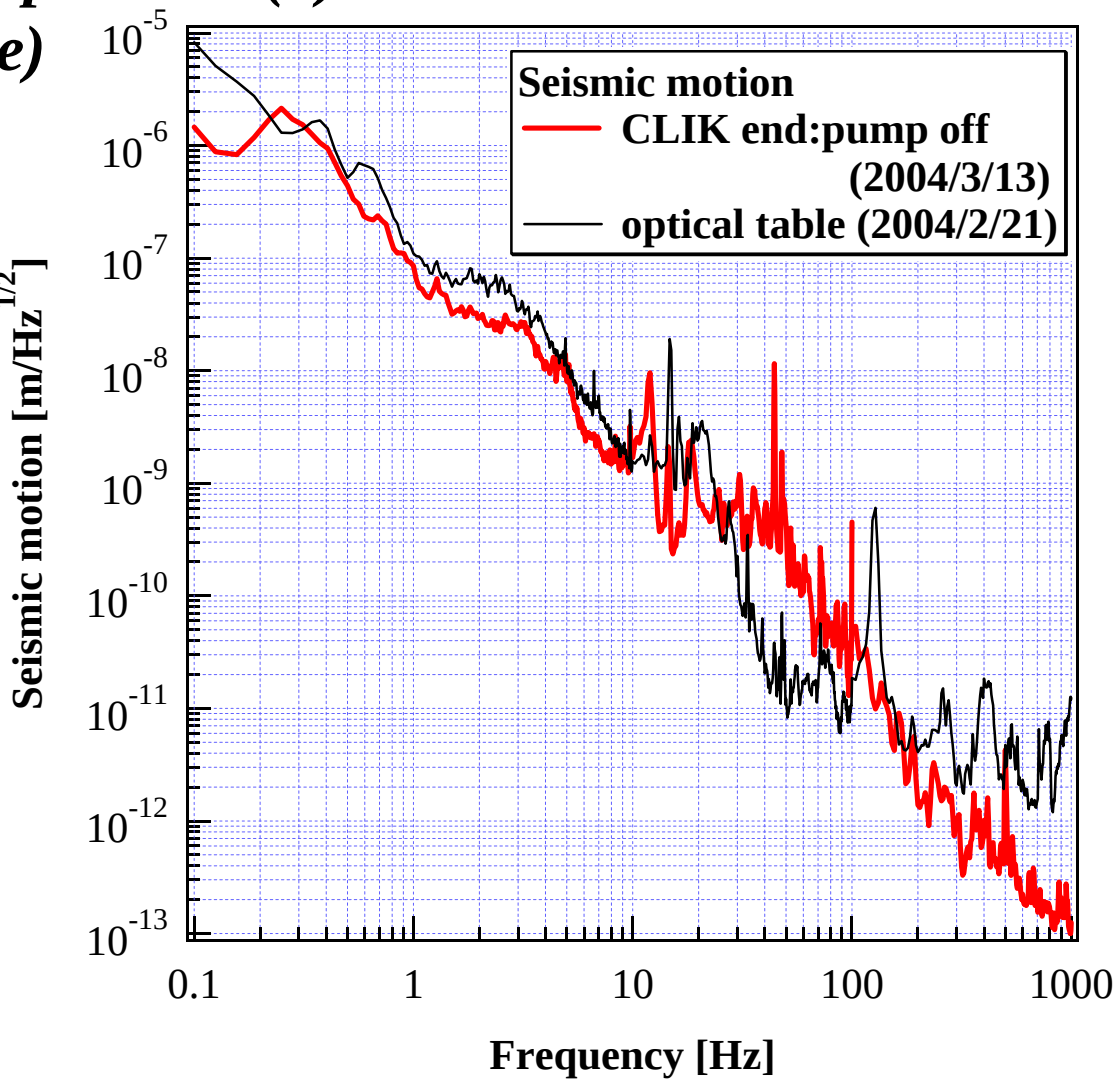
- 30 Hz : about same

30 Hz -100 Hz :

larger motion
in cryostat

100 Hz - :

better sound isolation
in cryostat



3-3. Operation at room temperature (3)
(Effect of pump vibration)

Peaks

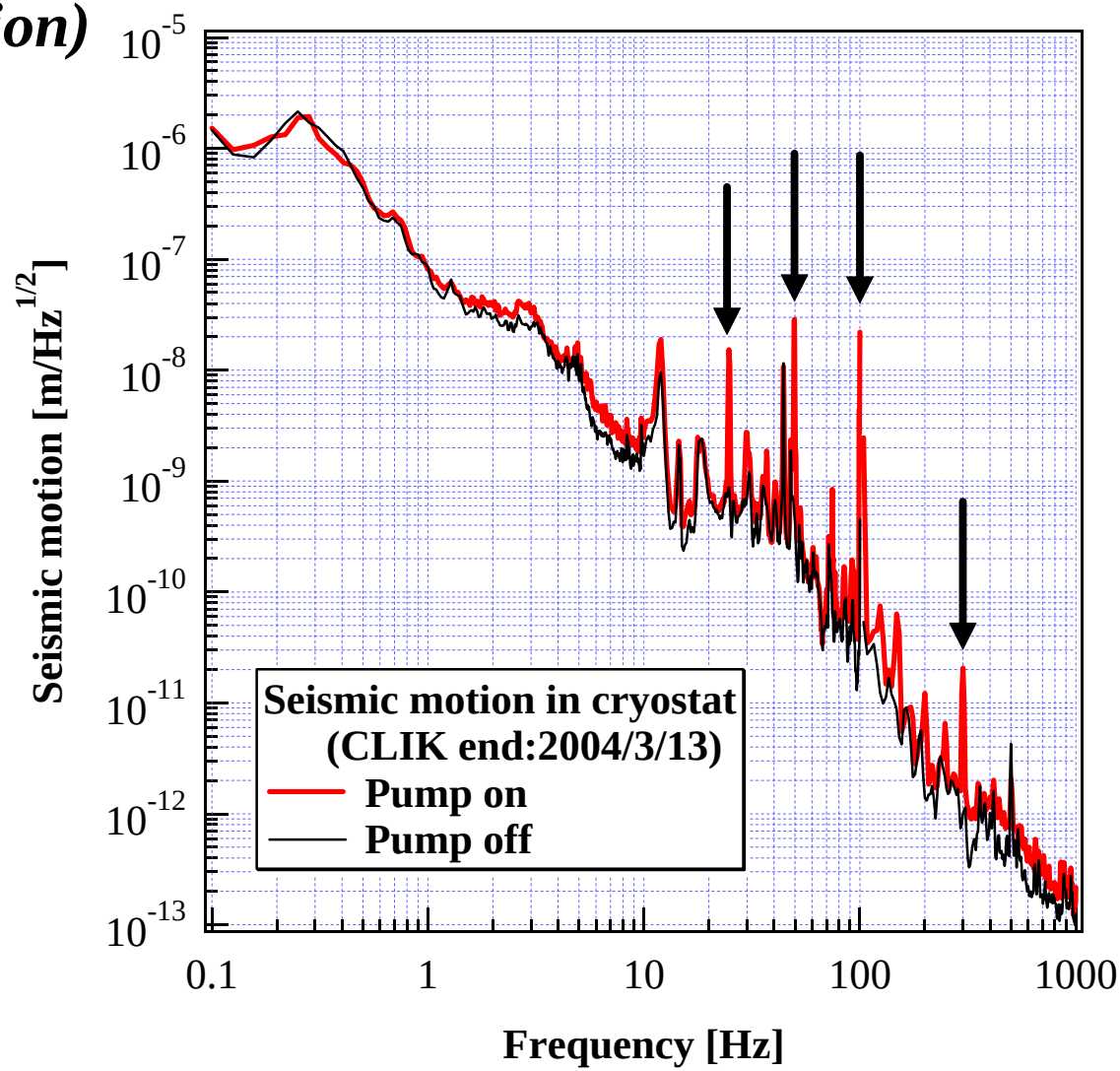
25, 50, 100, 300 Hz

↑

Rotary pump

Floor level

no change



3-4. operation at low temperature

Problems

(i) Unlock : Gifford-McMahon refrigerator causes large vibration.

(ii) Fringe was lost.

3-4. operation at low temperature

Problems

(i) Unlock : Gifford-McMahon refrigerator causes large vibration.

(ii) Fringe was lost.

⟶ Mirror of oscillator dropped !

There are no other problems.

4. Future works

(1) Measurement at low temperature in Kashiwa (CLIK)

(2) Measurement of vertical vibration in Kashiwa (CLIK)

2004 May ? : Cryogenic parts of CLIO project will be installed in Kamioka mine.

(3) Measurement in CLIO cryostat in Kamioka mine

Cryostat of CLIO interferometer

5. Summary

(1) Development of the accelerometer

for cryogenic interferometer (LCGT and CLIO) ...

(2) Operation at room temperature : no serious problems

and some results

(3) Operation at low temperature : some problems

(4) Future works : operation at low temperature

measurement in CLIO cryostat

Interferometer noise