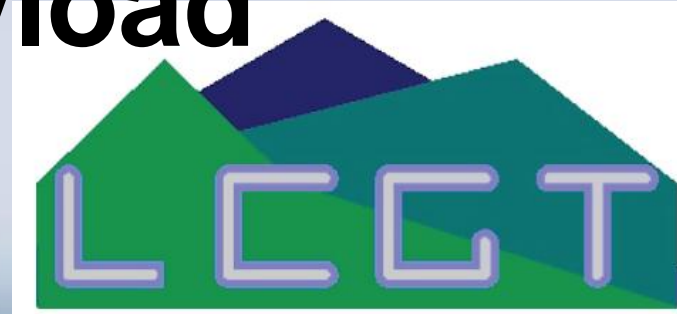


Report from sub-groups

Cryogenic

Cryogenic payload



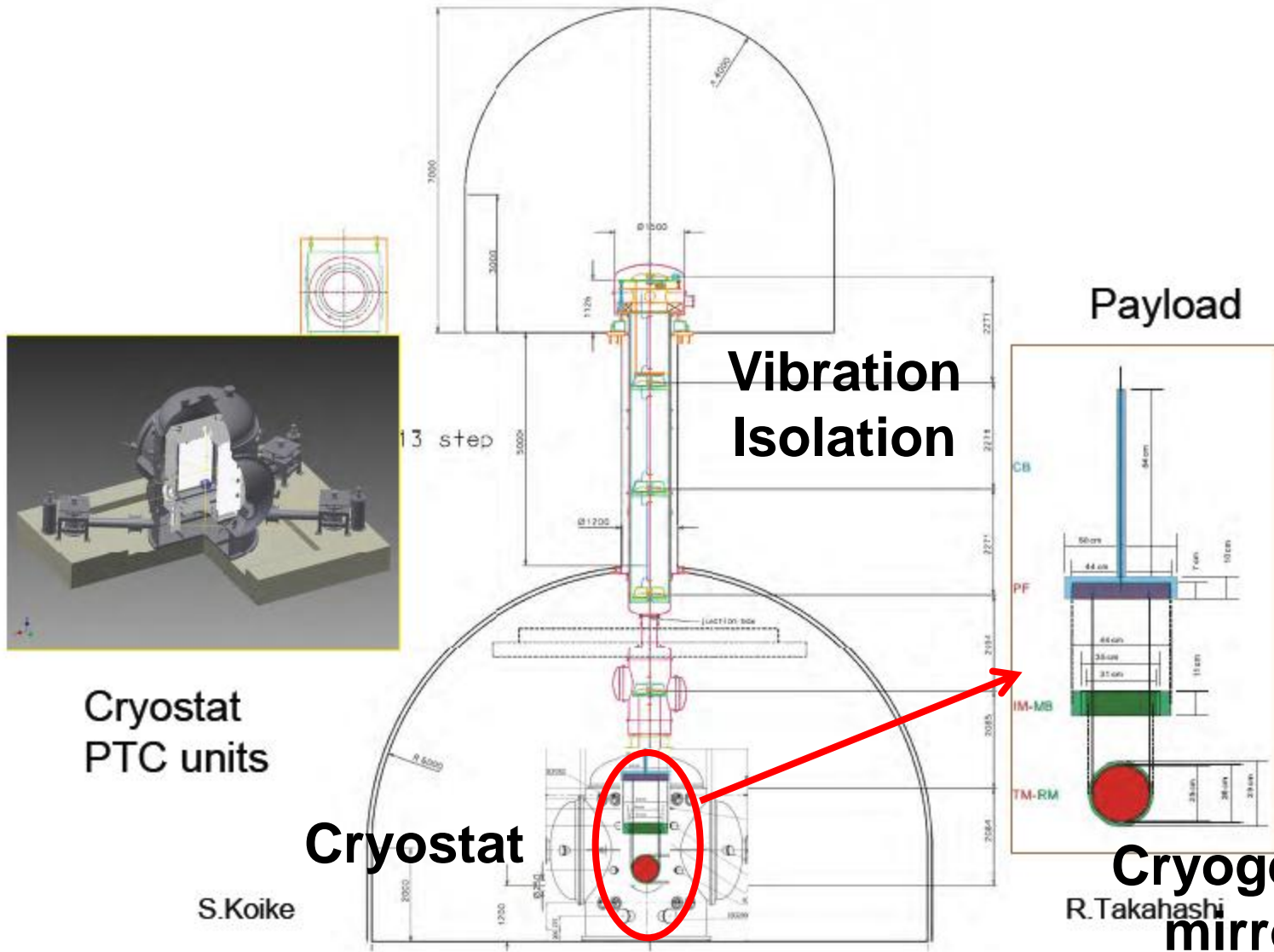
Kazuhiro Yamamoto

Institute for Cosmic Ray Research (ICRR)
the University of Tokyo

KAGRA(LCGT) face to face meeting
Institute for Cosmic Ray Research, Kashiwa, Japan
3 February 2012

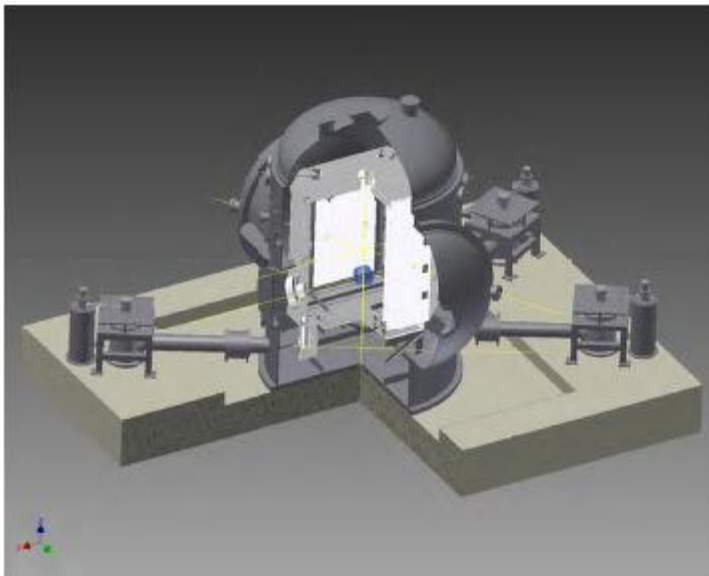
***I explain the cryogenic payload.
This is a part of **cryogenics**, but it is also
related with **vibration isolation system**.***

What is cryogenic payload ?

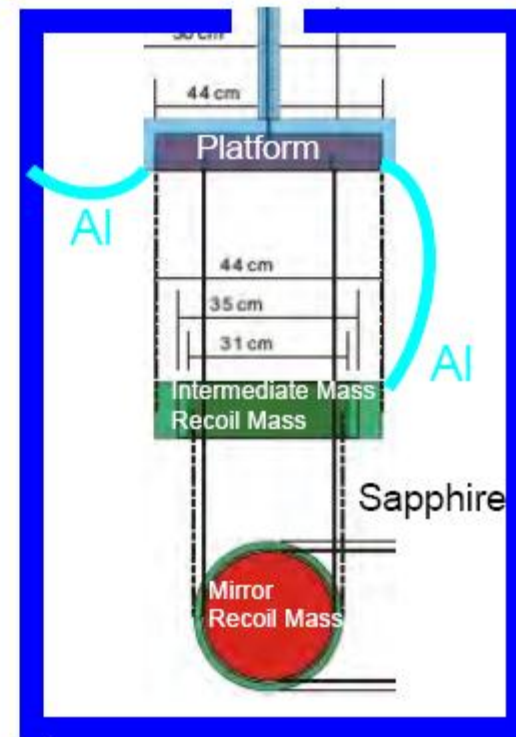


What is cryogenic payload ?

Cooling of payload



Double radiation shield
Low vib. PTC units
Pure Al heat path



What are issues ?

(1)How to assemble

Details of construction, clean room

(2)Strength

**Tensile strength, development of clamp,
sapphire bonding ...**

(3)Control and damping system

to reduce fluctuation and instability

Actuators (what and where),

resonant mode (frequency and Q)

and so on

What are issues ?

(4)Cooling

**Temperature of mirror (below 20 K),
initial cooling time,
heat resistance of clamp ...**

(5)Noise

**Thermal noise, vibration via
vibration isolation system and heat links ...**

Outline of strategy

Cryogenic payload is **not necessary in iKAGRA** (-2015) because room temperature interferometer will be constructed.

However, the development and installation should be **in progress** for bKAGRA (2016-) **in iKAGRA phase.**

For **bKAGRA**,

(a) Experiment of **1/4 cryostat**

in ICRR to check payload

1/4 means number of cryocooler, not size.

(b) Other **R&D**

(c) A part of **installation in Kamioka mine** should be in progress **in iKAGRA phase.**

Schedule

Now, the design of **1/4 cryostat** and R&D
are in progress.

-2013 Mar : **1/4 cryostat** will **arrive at ICRR**.

2013 Apr -2014 Sep : **Experiment** of 1/4 prototype
R&D items

2014 Jul -2015 Mar : **Procurement** for bKAGRA

Middle of 2015 – End of 2016:

Installation and test in Kamioka mine
(End of 2015 : iKAGRA Observation)

2017 Sep – 2018 Mar : **Cryogenic operation**

2018 Apr – : **Tuning and observation**

Items in iKAGRA phase

(1) **1/4 cryostat** in ICRR

Many items of **cryogenic payload**

will be **checked**.

(a) How to assemble and install

(b) Cooling test

(c) Control and damping

Items in iKAGRA phase

(2) Other R&D items

(a) How to suspend mirrors

using sapphire fibers

(b) Vertical spring in cryostat

(c) Development and test

of sensors, actuators, motors in cryostat

(d) Thermal noise (Q measurement

of wires and coating and so on)

(e) Seismic noise, external vibration noise

(vibration of shield, transfer function of heat link)

(f) Baffles for scattered light

Current Status

Cryogenic payload meeting

(almost) every month from July 2011

<http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/LCGT/subgroup/vacuum>

Mailing list : 23 members

Anybody is welcomed !

Current Status

Preparation for 1/4 cryostat (C. Tokoku)

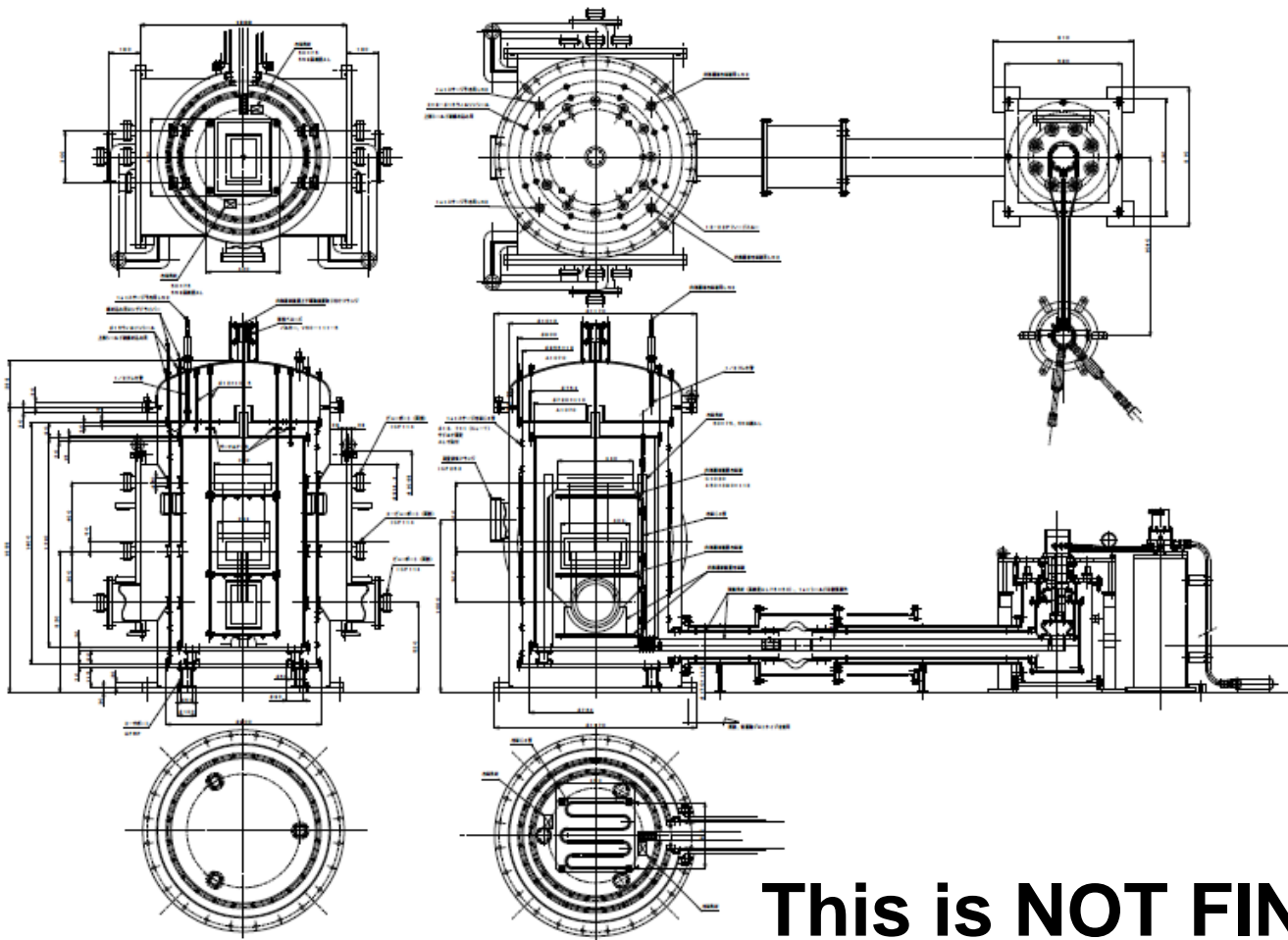
Cryocooler has already arrived at ICRR !



Current Status

Preparation for 1/4 cryostat

Design of **1/4 cryostat** is in progress.



This is NOT FINAL version. 13

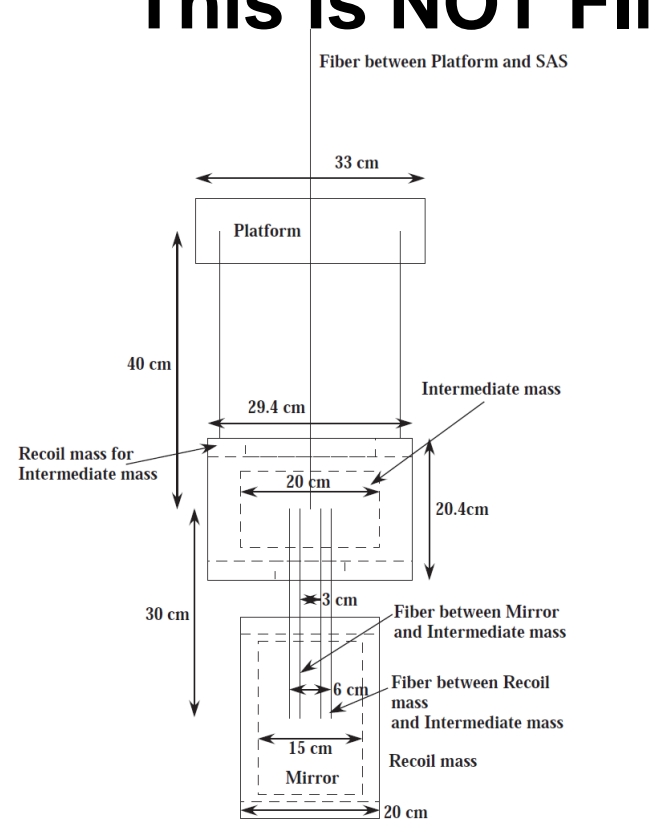
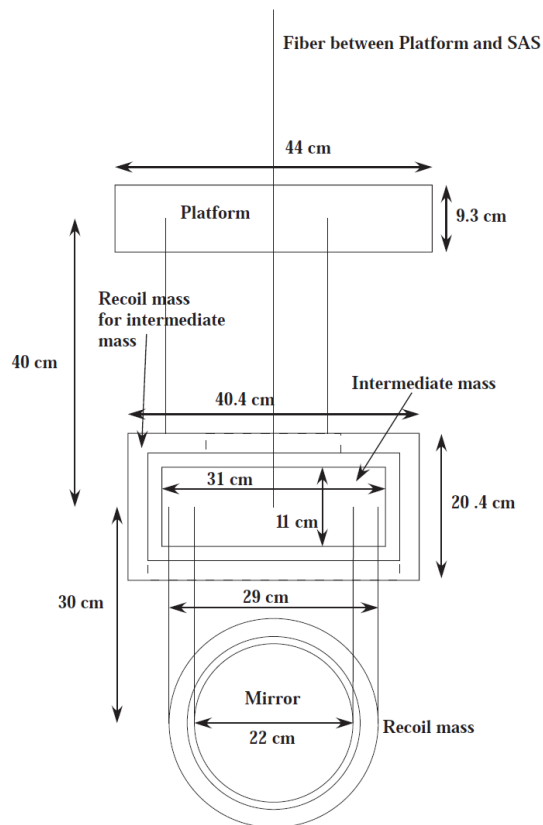
Current Status

Preparation for 1/4 cryostat

Design of **cryogenic payload** is in progress.

We should revise ICD as soon as possible.

This is NOT FINAL version.

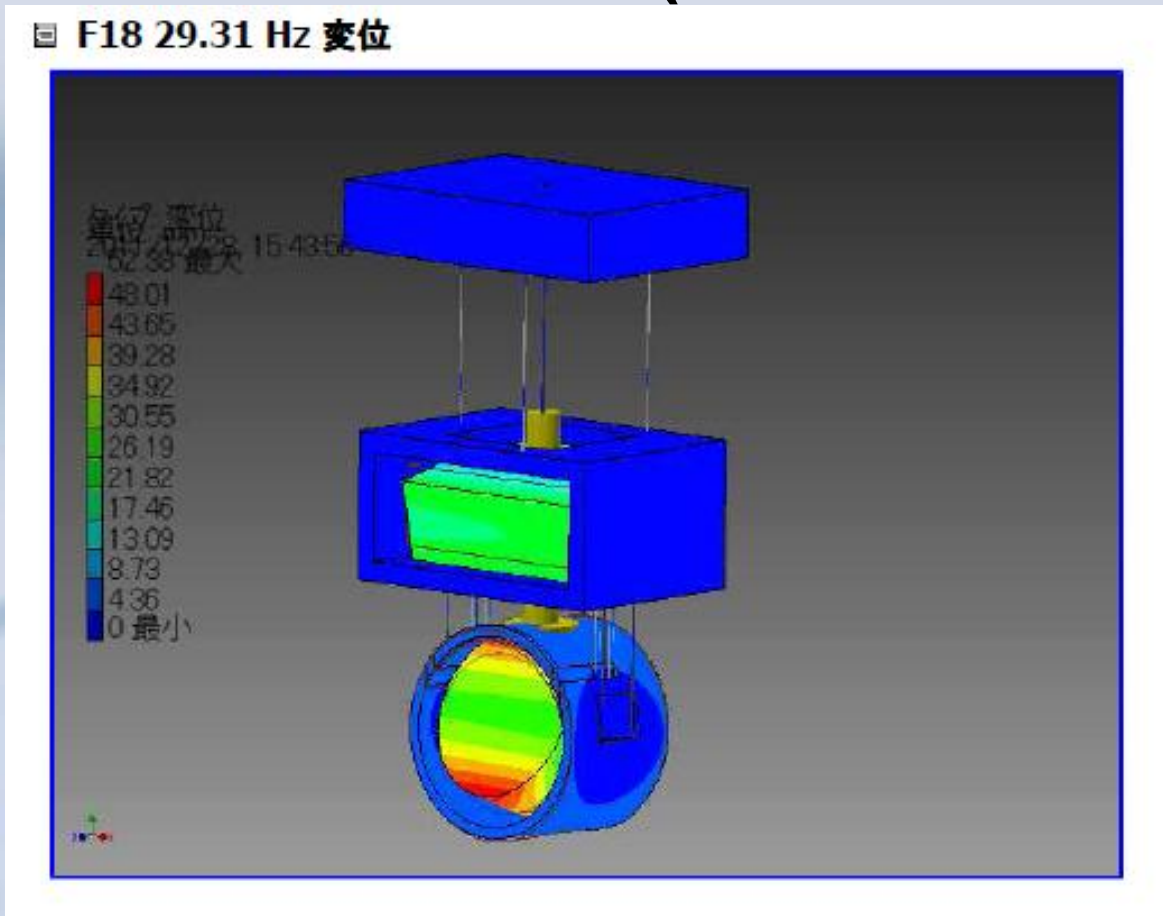


Current Status

Preparation for 1/4 cryostat

Thermal and mechanical simulation of payload

(S. Koike and T. Sekiguchi)



Current Status

Preparation for 1/4 cryostat

Selection of material of wires and masses

(C. Tokoku)

Material of wires and masses except for (sapphire) mirrors and (sapphire) fibers for mirrors are still open questions.

Measurement of RRR is in progress.

Latest result : RRR of Cu-Sn is about 10.

Thermal noise by eddy current is almost independent of temperature.

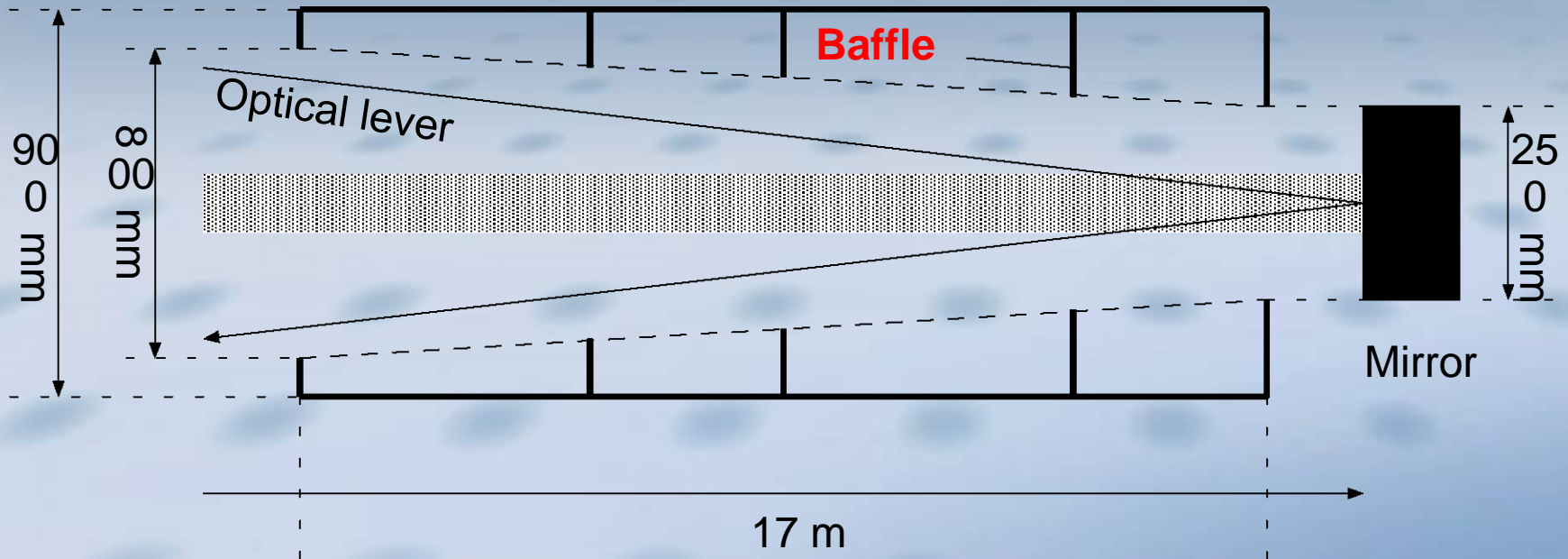
Current Status

Preparation for 1/4 cryostat

Duct shields for reduction of 300 K radiation

(Y. Sakakibara)

His simulation shows how we can **reduce 300 K radiation sufficiently**. Paper is preparing.



Current Status

Preparation for 1/4 cryostat

Duct shields for reduction of 300 K radiation

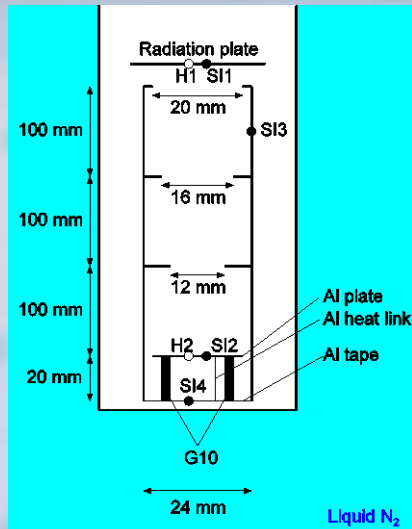
(Y. Sakakibara)

Small **experiment to check his simulation is in progress** by himself.

1/4 cryostat also will be used for this experiment.

H : Heater

SI : Thermometer



Current Status

Preparation for 1/4 cryostat

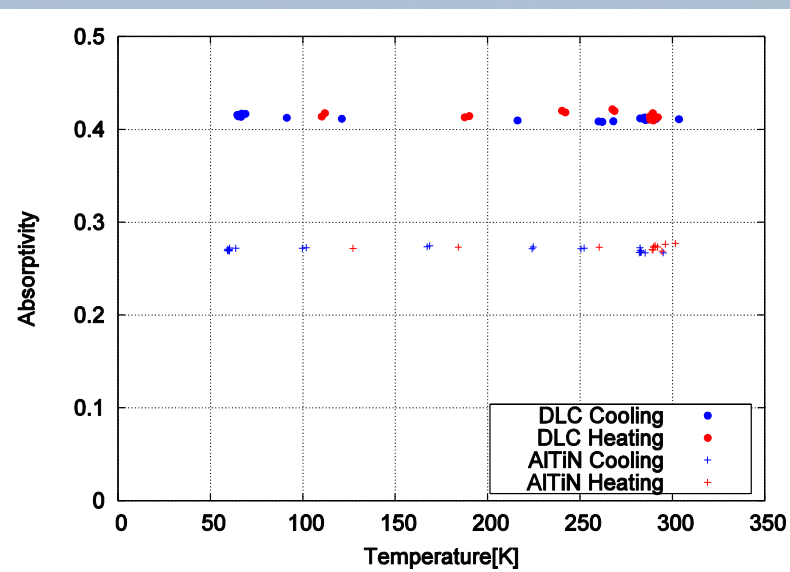
Duct shields for reduction of 300 K radiation

(Y. Sakakibara)

Other Sakakibara result

Simulation of initial cooling time

Measurement of reflectance of Diamond Like Carbon (DLC) to absorb 300 K radiation



Current Status

Sapphire fibers to suspend sapphire mirrors

Class. Quantum Grav. 27 (2010) 084021

M Lorenzini

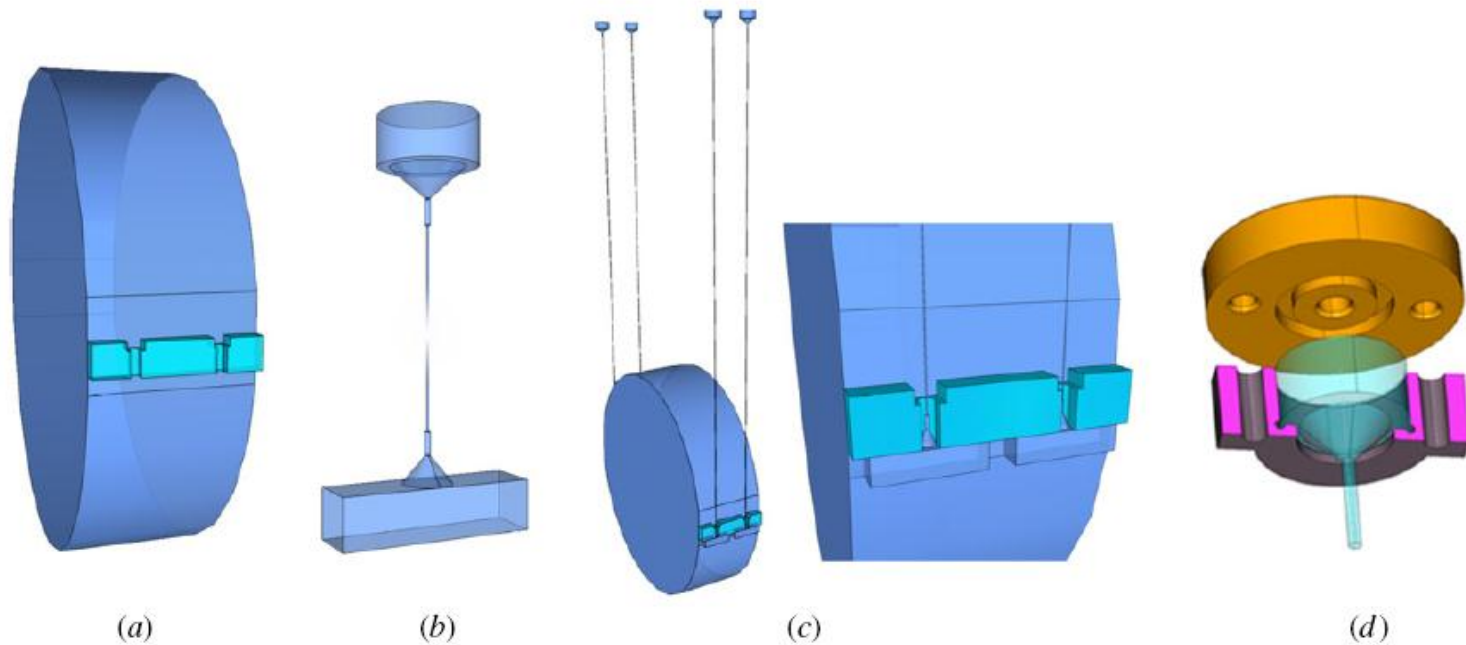
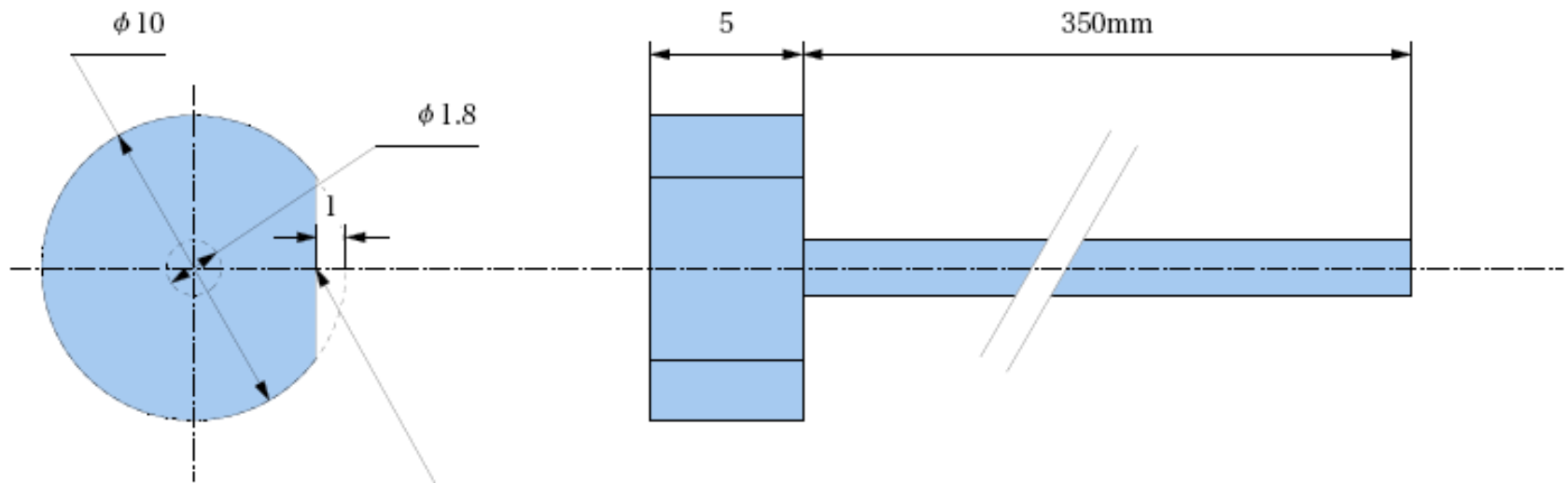


Figure 2. Sketch of the steps followed to realize a monolithic suspension, as detailed in the text.

Current Status

Sapphire fibers to suspend sapphire mirrors

Test sample (T. Uchiyama)



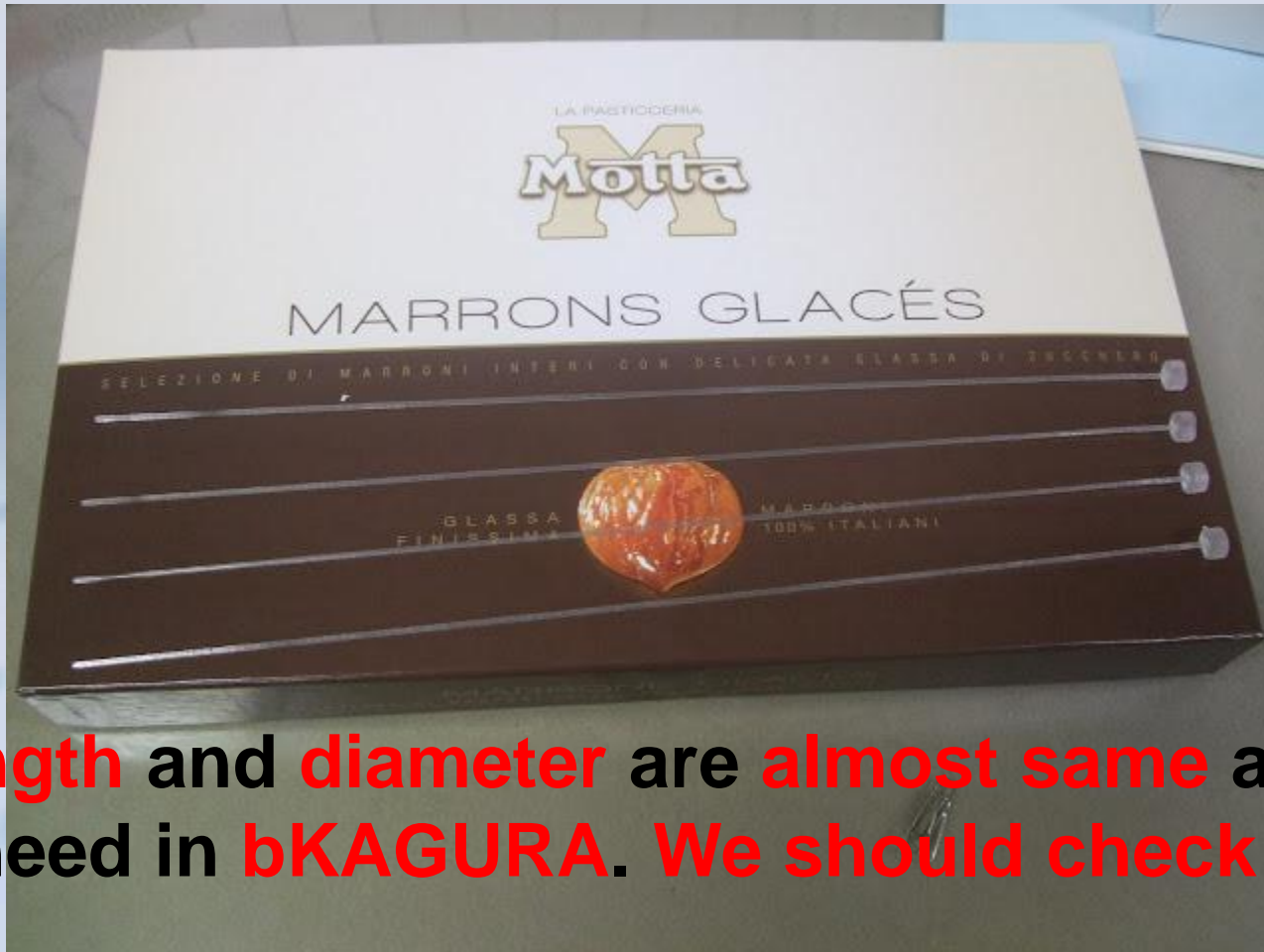
Orientation flat indicating the crystal axis which is perpendicular to the crystal axis of the fiber growing up direction.

Core diameter: 1.8mm.
Core length: 350mm.
Edge diameter: 10.0mm.
Edge length: 5mm.
2011/09/16
Takashi Uchiyama
ICRR, the Univ. of Tokyo.

Current Status

Sapphire fibers to suspend sapphire mirrors

Sapphire fibers from MolTech GmbH (Germany)



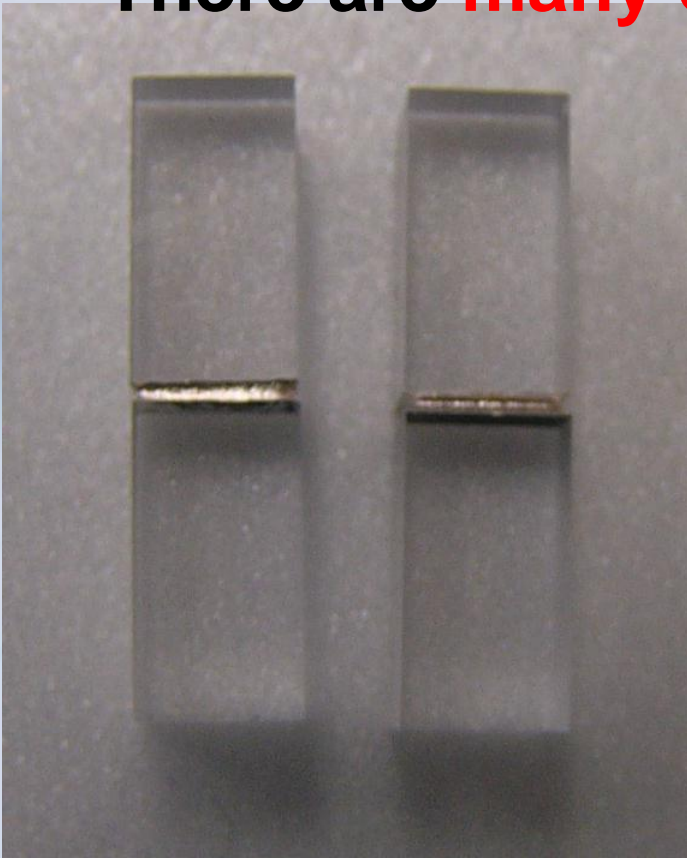
Thier length and diameter are almost same as what we will need in bKAGURA. We should check the quality.

Current Status

Sapphire fibers to suspend sapphire mirrors

Bonding (between sapphire fibers and mirrors)

There are **many candidates**.



Thermal conductivity are measured by K. Shibata, T. Ushiba, T. Suzuki.

Q-values and strength should be measured.

Metalize bonding (Kyocera)

Current Status

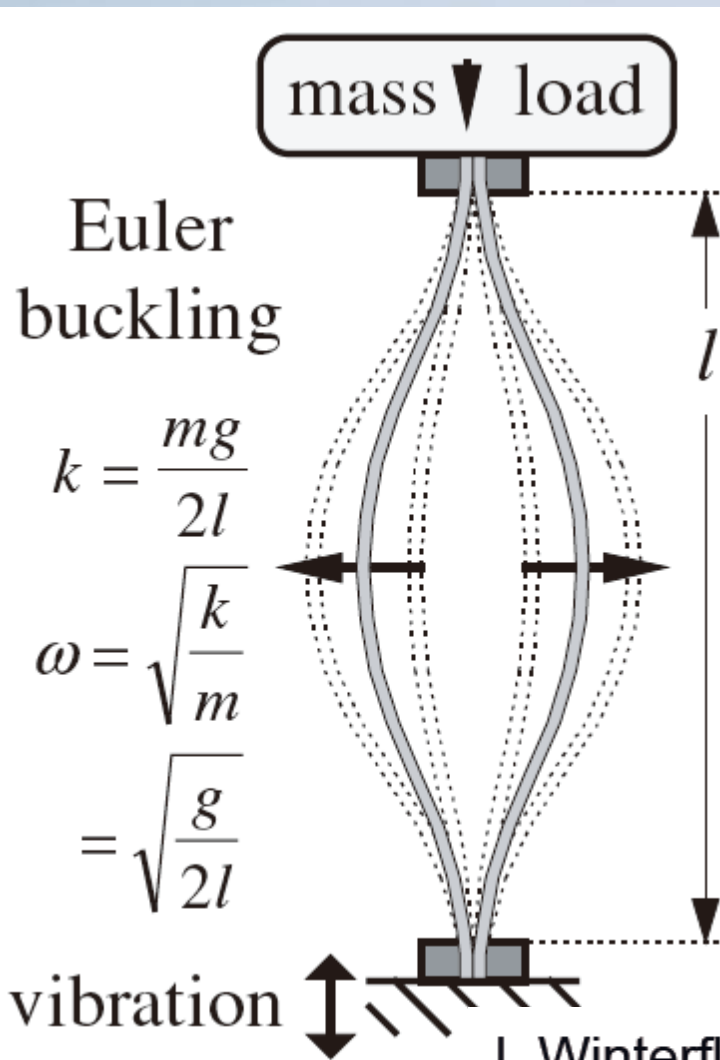
Sapphire fibers to suspend sapphire mirrors Bonding (between sapphire fibers and mirrors)

Known methods of bonding

	Precise polish	Interposition material	Temperature treatment	Sapphire-Sapphire	Thermal conductance	Mechanical loss
AFB, Diffusion	Necessary	none	1300~1400 °C	Almost same as bulk ~ 28 MPa	~ 20 W/K	Not yet measured
Direct, SAB1 (~ 2000)	Necessary	None (Ar ⁺ beam)	300 K	-	-	Not yet measured
Direct, SAB2 (2011)	Necessary	Fe, etc (Ar ⁺ beam)	300 K	Not yet measured	Not yet measured	Not yet measured
Hydroxy-catalysis, silicate	Necessary	KOH, Na ₂ SiO ₃ , H ₂ O	300 K	~ 7 MPa	~ 7 W/K	Not yet measured
Metalize, soldering	(Not required)	Active metal	< 1000 °C?	Not yet measured	Not yet measured	Not yet measured
Adhesive	Not required	Al ₂ O ₃ , AlPO ₄ , H ₂ O	~ 500 °C	~20 MPa	Not yet measured	Not yet measured

Current Status

Vertical spring in cryostat



H. Ishizaki is **developing**.

T. Sekiguchi will start the **investigation** of **Maraging steel**.

R. DeSalvo; no spring in cryostat or silicon spring ?

Current Status

Thermal noise

T. Sekiguchi calculated the suspension thermal noise **with non-uniform diameter fibers** (to enhance thermal conduction).

His talk is at **10:30 on 4th of Feb (Sat)**.

E. Hirose and K. Yamamoto

: measurement of mechanical loss of coating

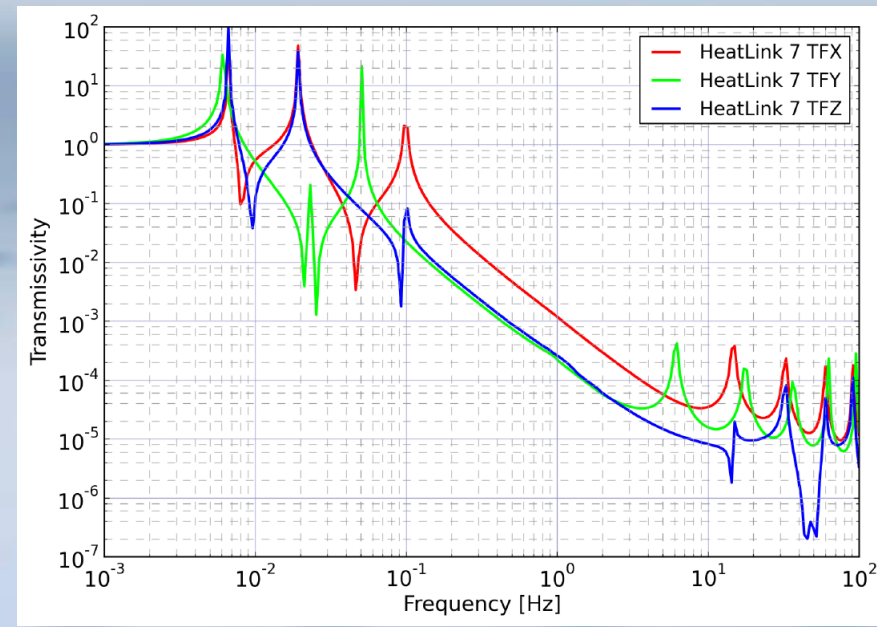
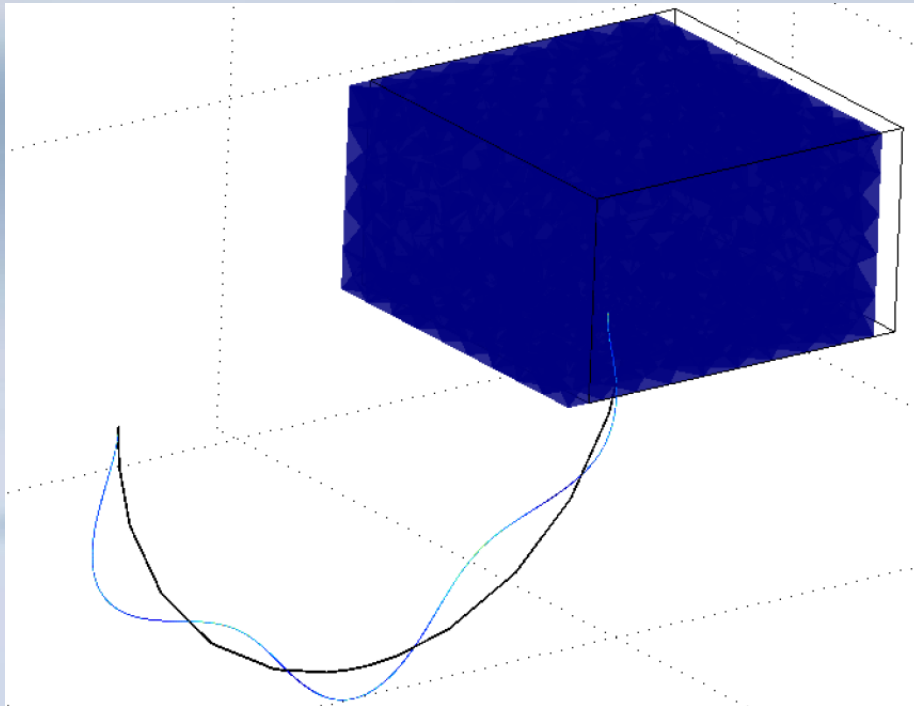
Current Status

Seismic noise, external vibration noise

Simulation of mechanical transfer function

of the heat link by Y. Aso

<http://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=108>

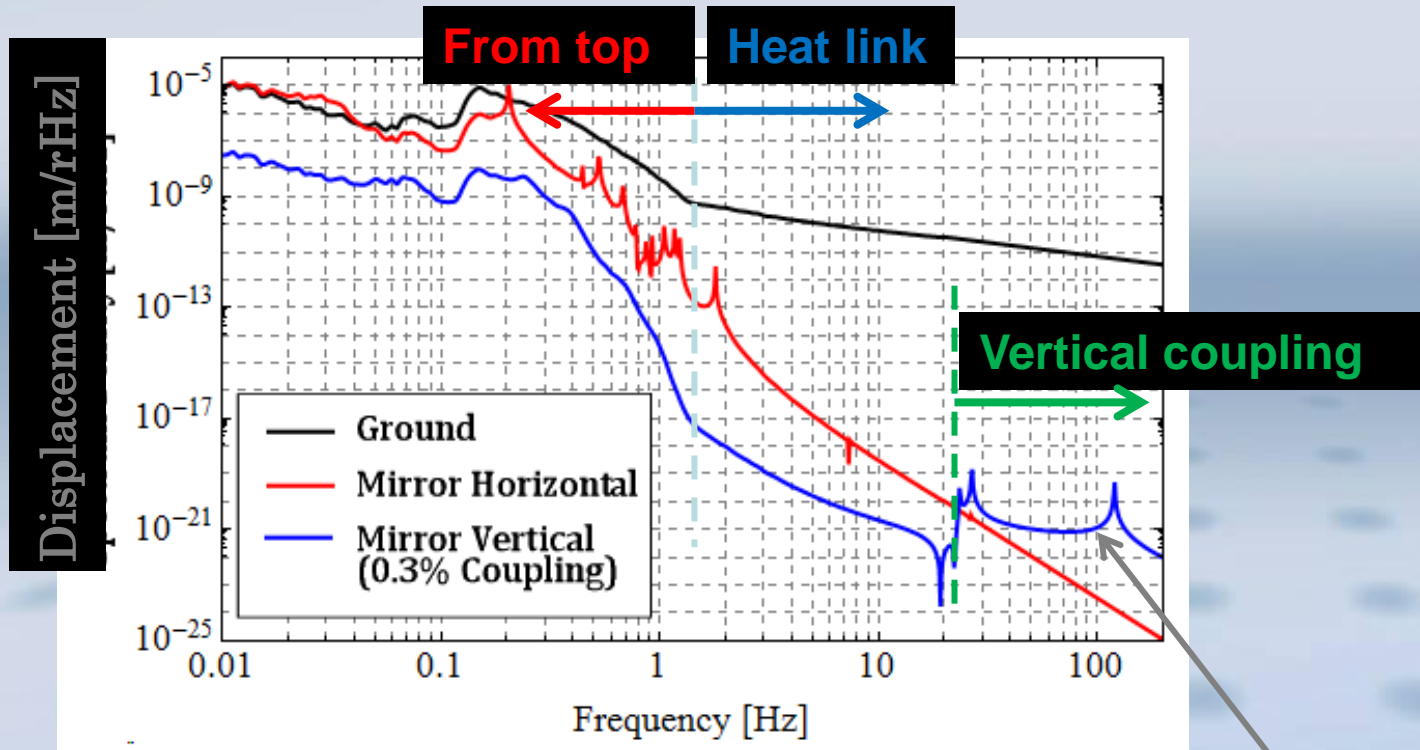


Measurement of vibration of shield is necessary.

Current Status

Seismic noise, external vibration noise

Simulation of seismic motion by T. Sekiguchi



*Assuming 0.3% coupling from vertical vibration

10^{-21} m/ $\sqrt{\text{Hz}}$ at 100Hz

Measurement of vibration of shield and careful design for heat links are necessary.

Current Status

Baffles for scattered light

T. Akutsu (Auxiliary Optics) pointed out that **baffles for scattered light** might be put **in cryostat**.

However,

where are they put ?

how are they suspend for vibration isolation ?

how the heat by the light absorption is extracted ?

The discussion starts.

Human resources

1/4 cryostat and **R&D items** in iKAGRA are sources of **themes for graduate students and post docs** (by 2015 March).

If you (or your students) are graduate students in **Ph.D. course**, the **strategy should be considered carefully**.

Items in iKAGRA phase

(1) 1/4 cryostat in ICRR

(a) How to assemble and install

(b) Cooling test

(c) Damping and control

(including parametric instability)

Items in iKAGRA phase

(2) Some R&D items

(a) How to suspend mirrors

using sapphire fibers

(b) Vertical spring in cryostat

(c) Development and test

of sensors, actuators, motors in cryostat

(position and angle fluctuation of mirrors,

and instability)

(d) Thermal noise (Q measurement

of wires and coating and so on)

(e) Seismic noise, external vibration noise

(vibration of shield, transfer function of heat link)

(f) Baffles for scattered light

Thank you for your attention !