Report from sub-groups
Cryogenic
Cryogenic payload

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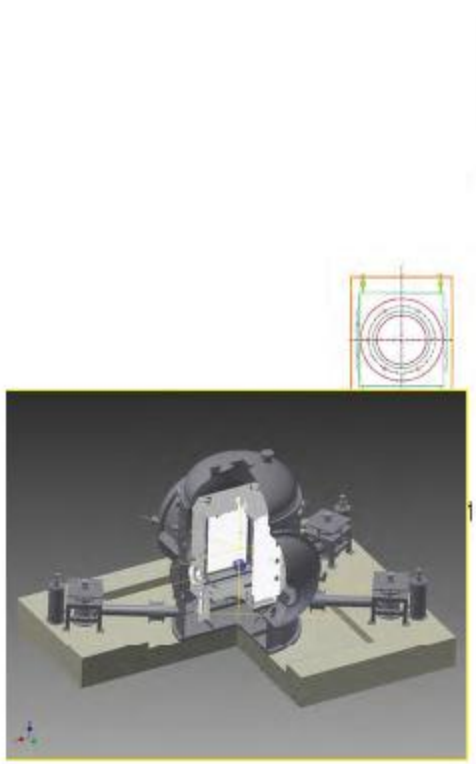
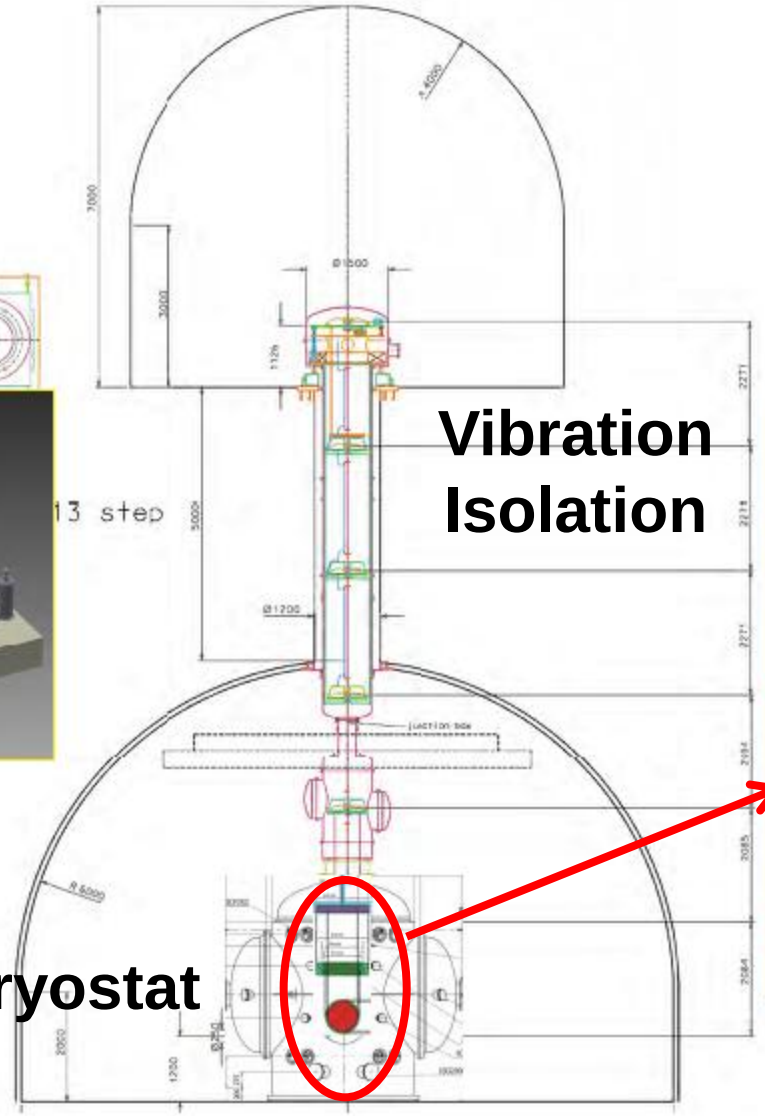
KAGRA(LCGT) face to face meeting
Institute for Cosmic Ray Research, Kashiwa, Japan
3 February 2012

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

What is cryogenic payload ?



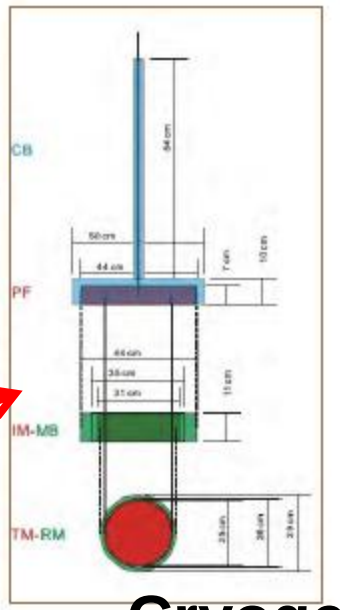
Cryostat
PTC units



Vibration
Isolation

Cryostat

S.Koike

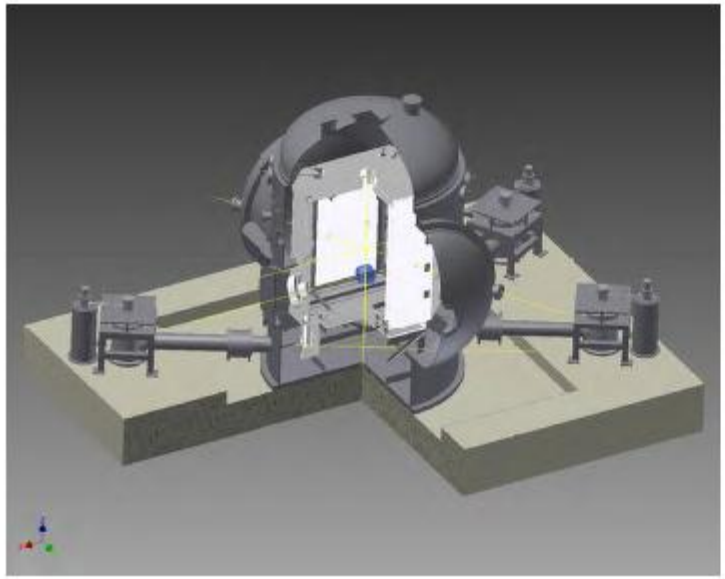


Cryogenic
mirror

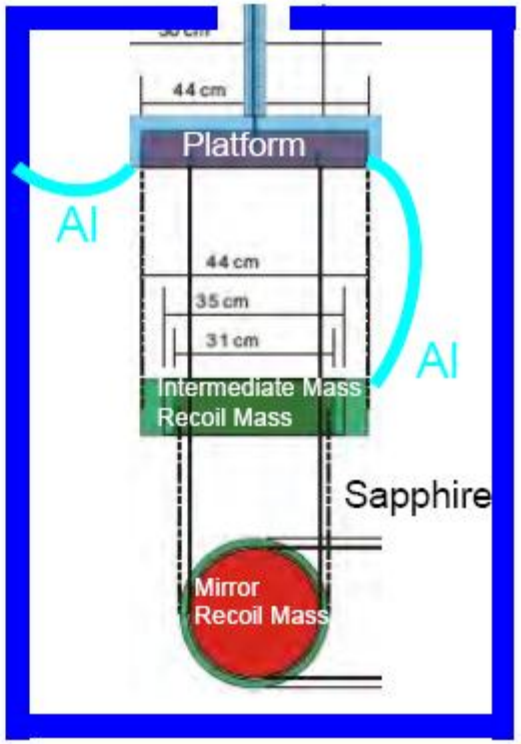
R.Takahashi

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

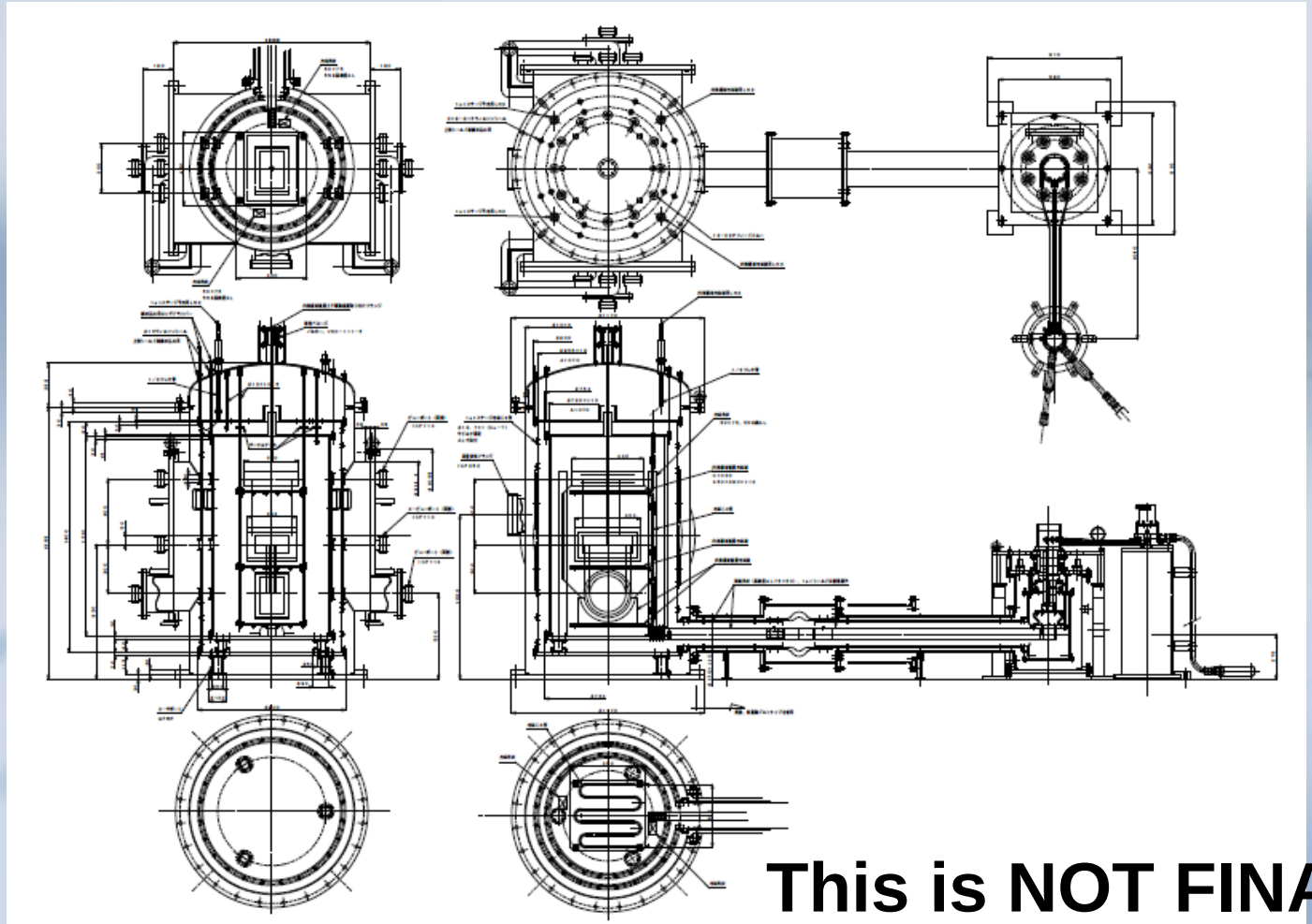
Preparation for 1/4 cryostat (C. Tokoku)

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.

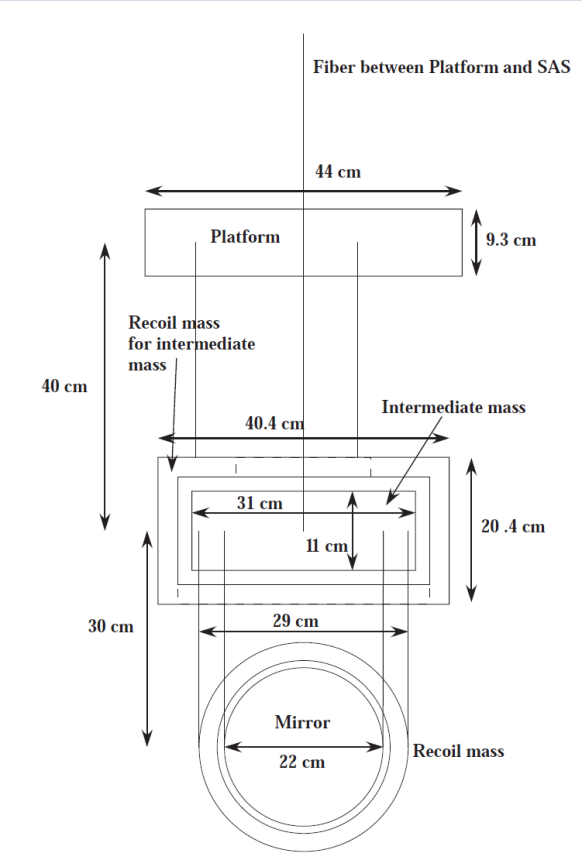
Current Status

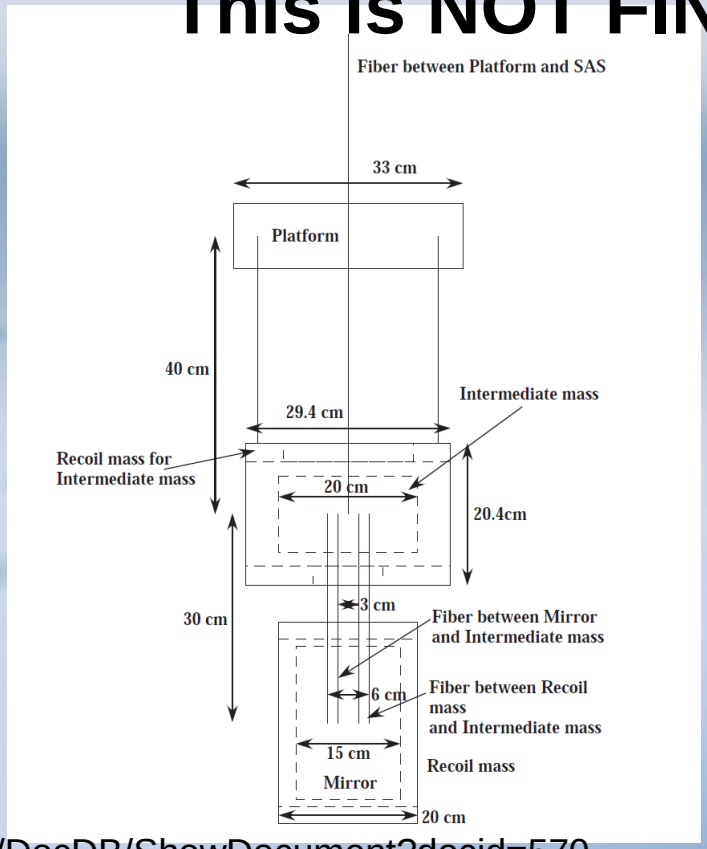
Preparation for 1/4 cryostat

Design of cryogenic payload is in progress.

We should revise ICD as soon as possible.

This is NOT FINAL version.

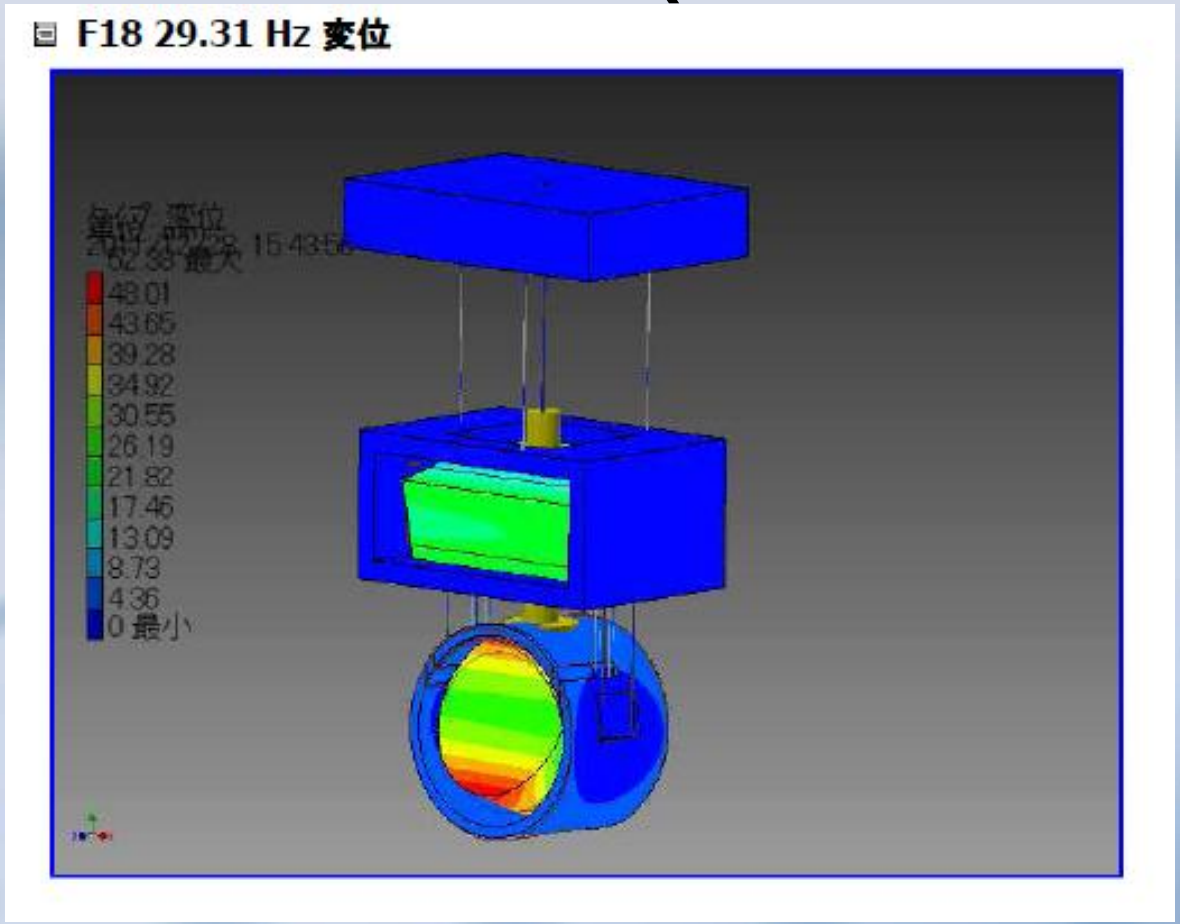




http://gwdoc.icrr.u-tokyo.ac.jp/cgi-bin/private/DocDB/ShowDocument?docid=570

Current Status

Preparation for 1/4 cryostat
Themal and mechanical simulation of payload
(S. Koike and T. Sekiguchi)



Current Status

Preparation for 1/4 cryostat
Selection of meterial 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.

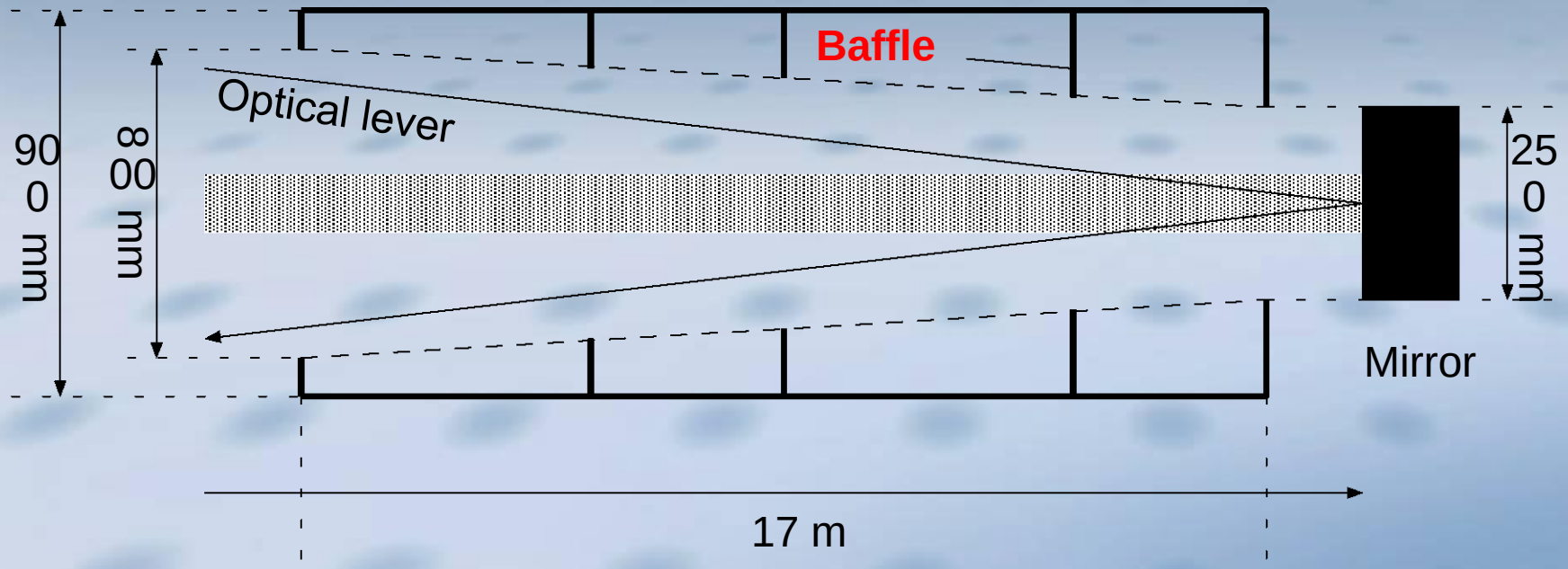
Current Status

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

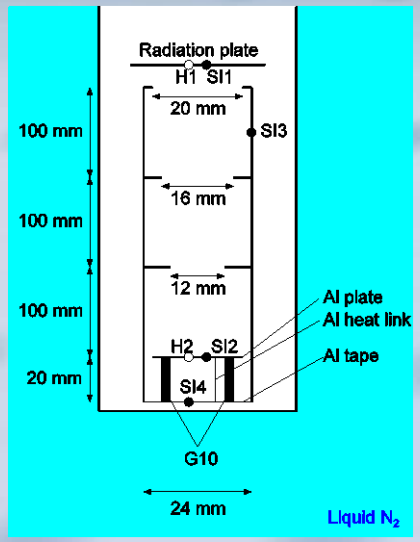
(Y. Sakakibara)

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

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

H : Heater

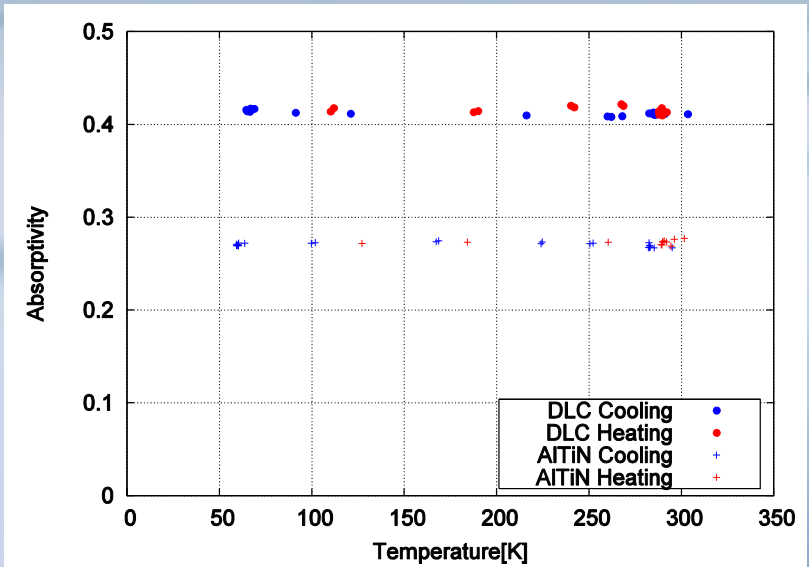
SI : Thermometer



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

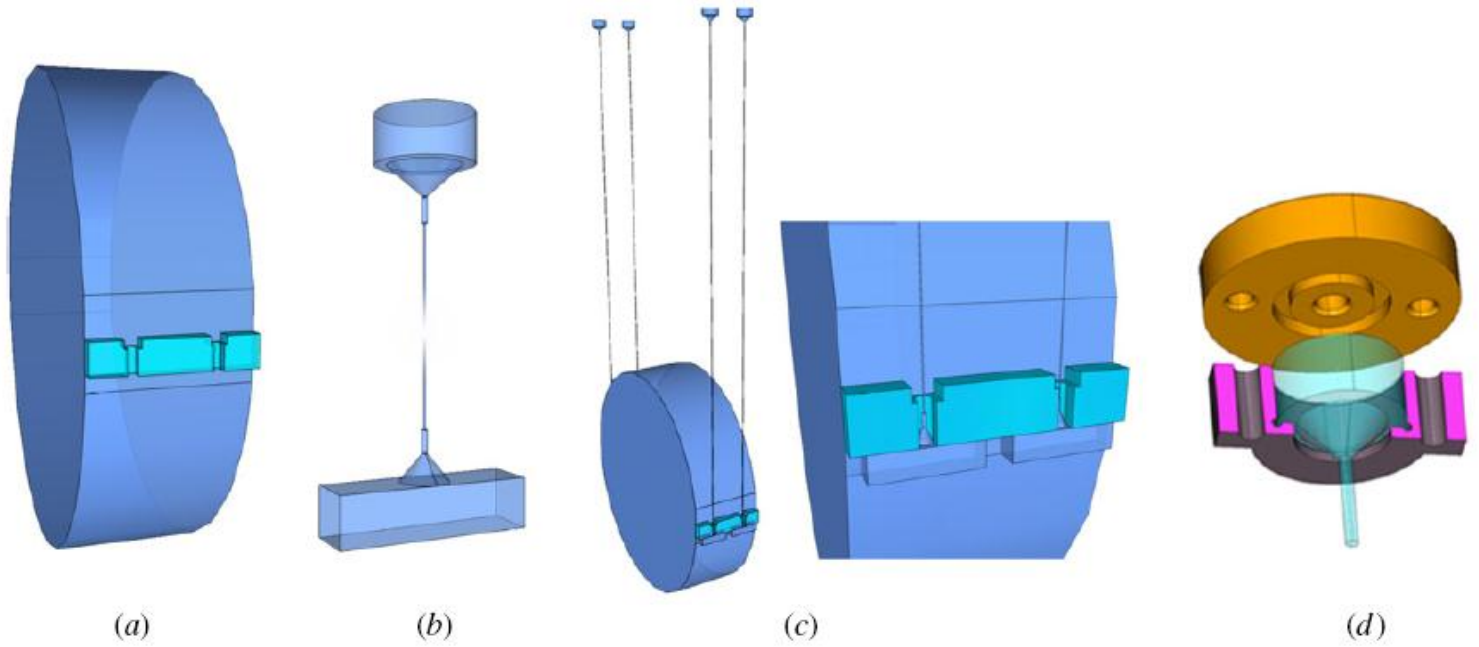
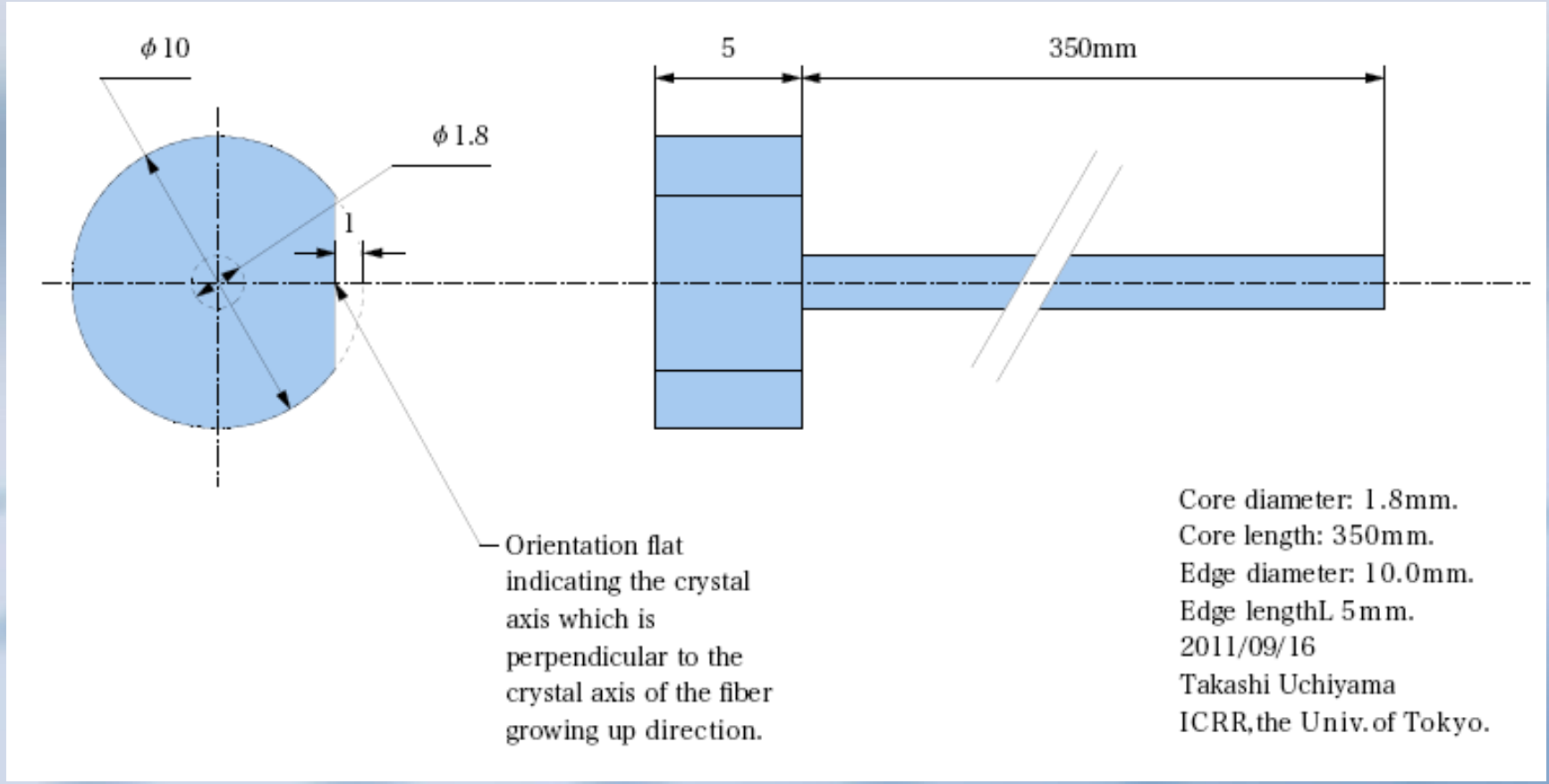


Figure 2. Sketch of the steps followed to realize a monolithic suspension, as detailed in the text.

Current Status

Sapphire fibers to suspend sapphire mirrors

Test sample (T. Uchiyama)



Current Status

Sapphire fibers to suspend sapphire mirrors

Sapphire fibers from MolTech GmbH (Germany)

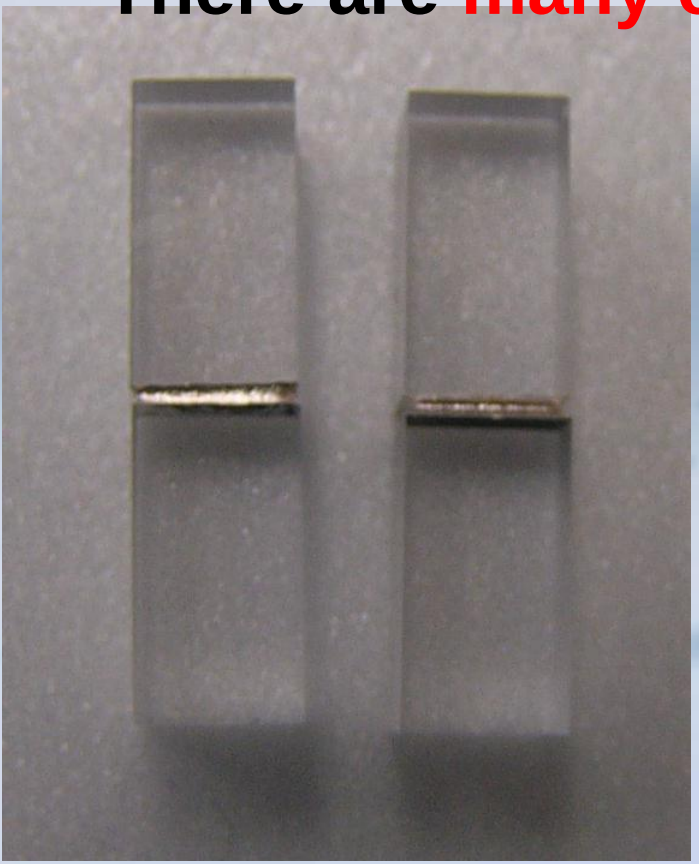
Thier length and diameter are almost same as what we will need in bKAGURA. We should check the quality.

Current Status

Sapphire fibers to suspend sapphire mirrors

Bonding (between sapphire fibers and mirrors)

There are many candidates.



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

Q-values and strength should be measrued.

Metalize bonding (Kyocera)

Current Status

Sapphire fibers to suspend sapphire mirrors

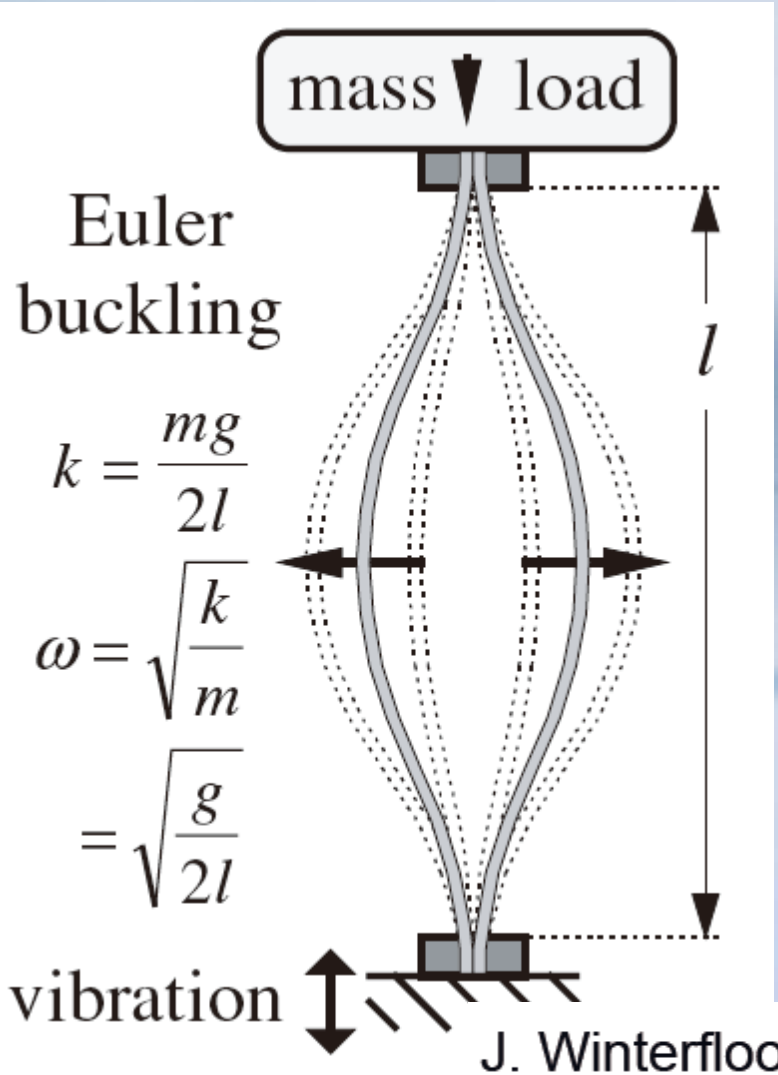
Bonding (between sapphire fibers and mirrors)

Known methods of bonding

	Precise polish	Interposition material	Temperature treatment	Sapphire-Sapphire	Thermal conductance	Mechanical loss
AFB, Diffusion	Necessary	none	1300~1400 ℃	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
Hyroxy-catalysis, silicate	Necessary	KOH, Na_2SiO_3, H_2O	300 K	~ 7 MPa	~ 7 W/K	Not yet measured
Metalize, soldering	(Not required)	Active metal	< 1000 ℃?	Not yet measured	Not yet measured	Not yet measured
Adhesive	Not required	Al_2O_3, $AlPO_4$, H_2O	~ 500 ℃	~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 ?

J. Winterflood, T. Barber, D. Blair: CQG 19 (2002) 1639

Current Status

Thermal noise

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

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

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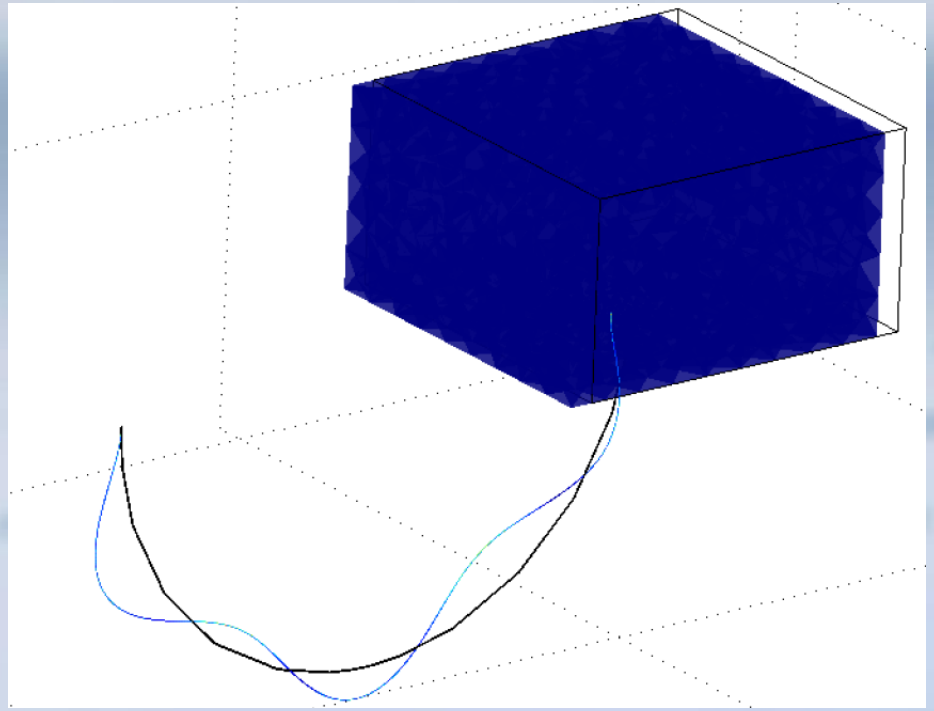

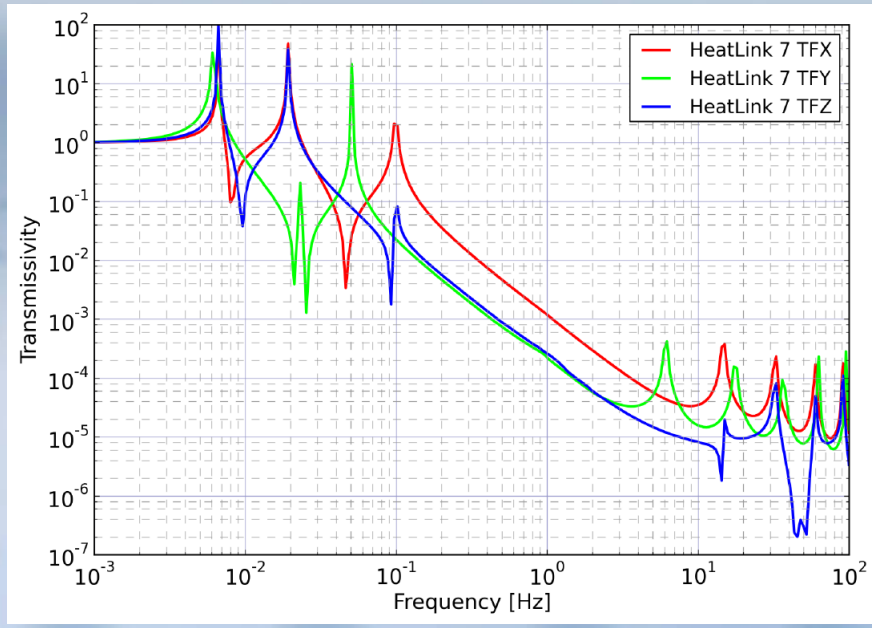

Measurement of vibration of shield is necessary.

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 !