

Current status of KAGRA Cryogenic

K. Yamamoto and KAGRA collaboration

**Institute for Cosmic Ray Research
the University of Tokyo**

16 May 2012

**Gravitational-Wave Advanced Detector Workshop
@Waikoloa Marriot Resort, Waikoloa Beach, Hawaii, U.S.A.**

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0. Abstract

**KAGRA : First km-scale
cryogenic interferometer**

It is being **constructed now !**

Progress for **cryogenic system**
of KAGRA in the **last one year**

Contents

- 1. Introduction***
- 2. Cryostat***
- 3. Cryocooler unit***
- 4. Cryogenic duct***
- 5. Cryogenic payload***
- 6. ELiTES***
- 7. Future Plan***
- 8. Summary***

1. Introduction

KAGRA (previously known as: LCGT)

2nd generation interferometer in Japan

Key feature of KAGRA project

Cryogenic system : Reduction of thermal noise

**I will explain the progress for cryogenic system
in the last one year.**

**Now, the first km-scale cryogenic interferometer
is being constructed !**

1. Introduction

Outline of cryostat and cryocoolers

Four mirrors of **arm cavity** will be **cooled**.

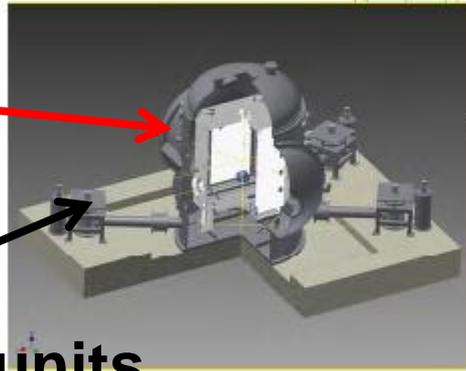


Vibration isolation system, Cryostat, Cryocooler unit, Cryogenic payload

1. Introduction

Outline of cryostat and cryocoolers

Cryostat



4 Cryocooler units

Cryostat
PTC units

Cryostat

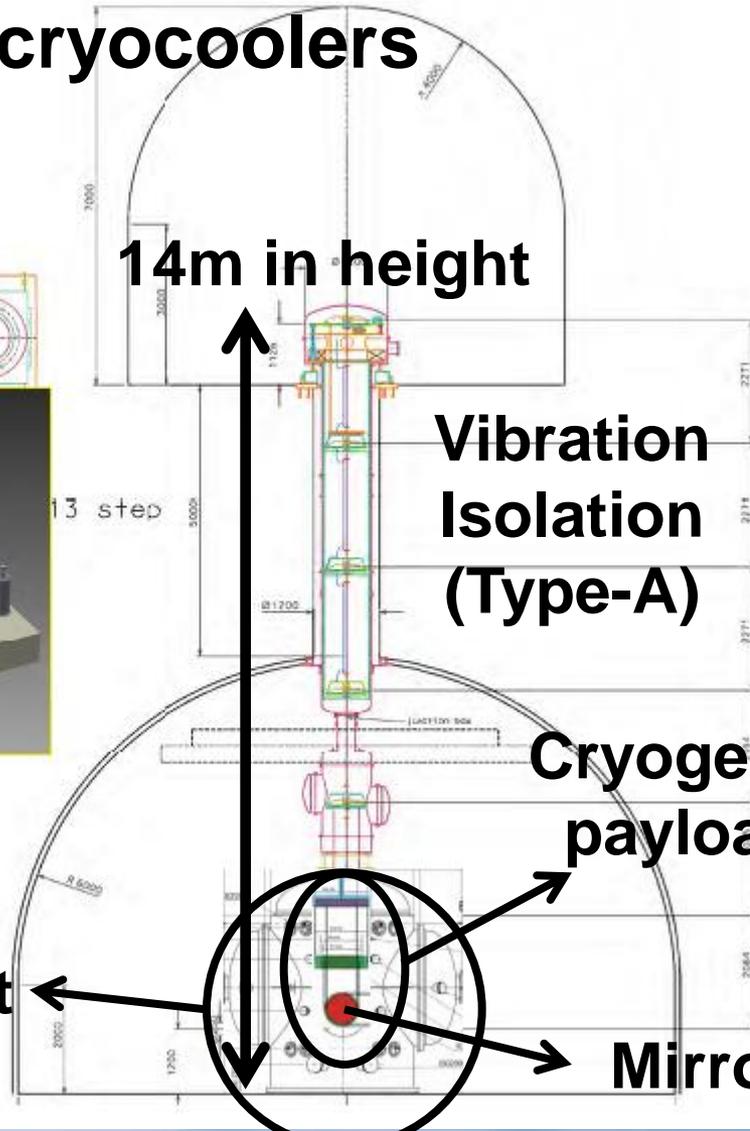
S.Koike

14m in height

Vibration
Isolation
(Type-A)

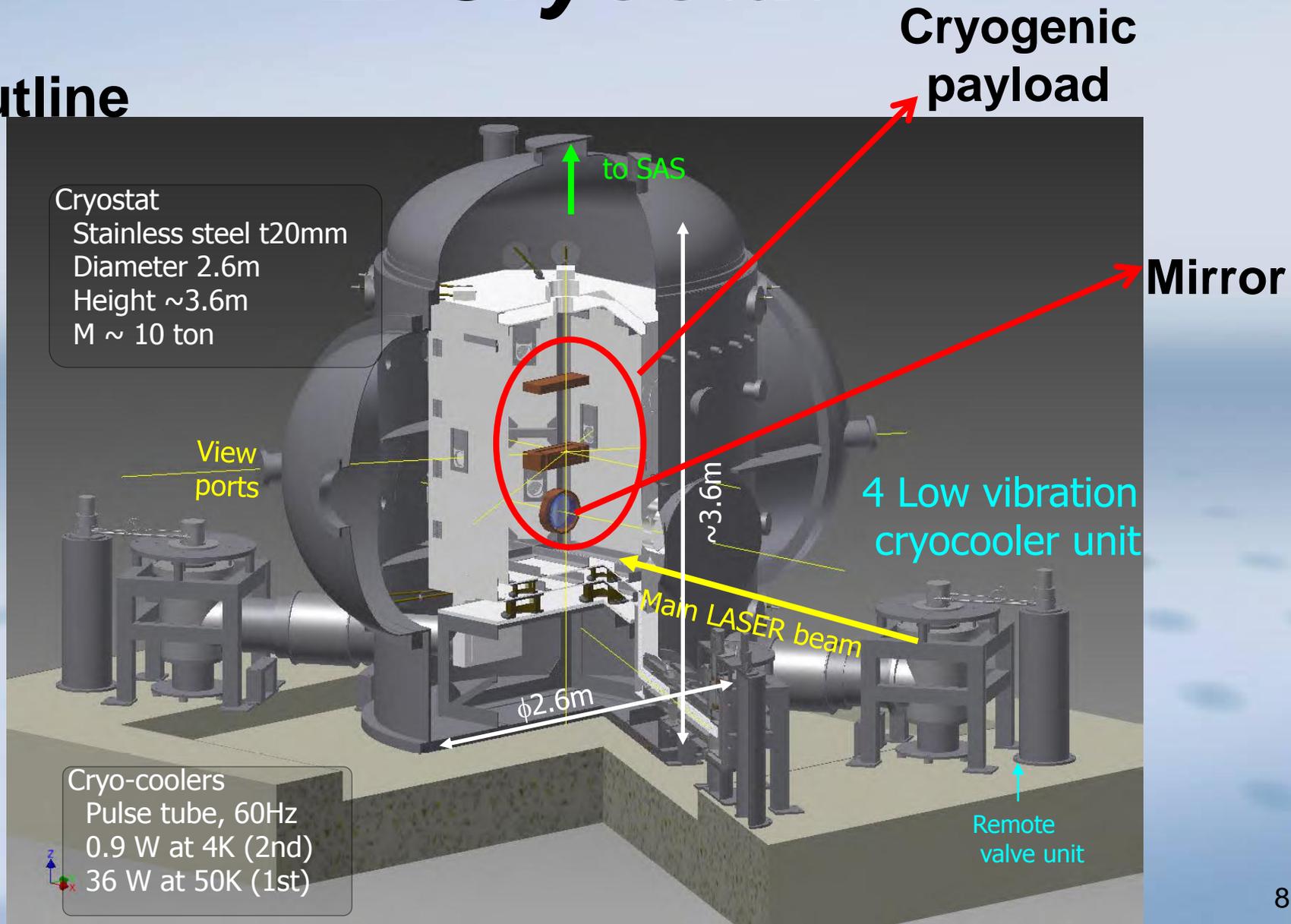
Cryogenic
payload

Mirror



2. Cryostat

1. Outline



2. Cryostat

3. Photos (Main body)

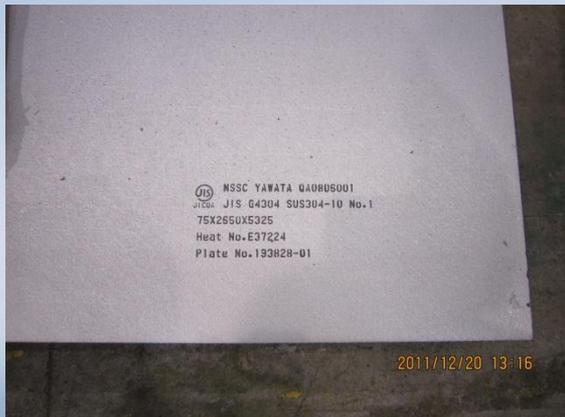


Main body ($\Phi 2.6\text{m}$, H3.6m)

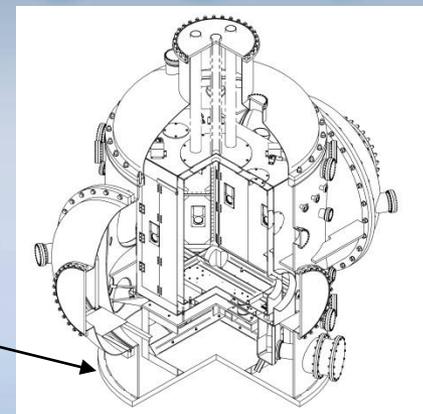


at Toshiba Keihin Factory

Cryostat Bottom plate SUS 304 t70



Daiwa Shearing Kasuga Factory



Toshiba Keihin Factory

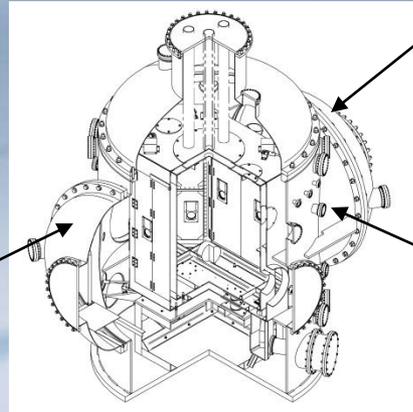
Cryostat Service port flange, side cap and tube



Shimoda Flange Aioi Factory



Flange ϕ 2200



Side cap ϕ 1970



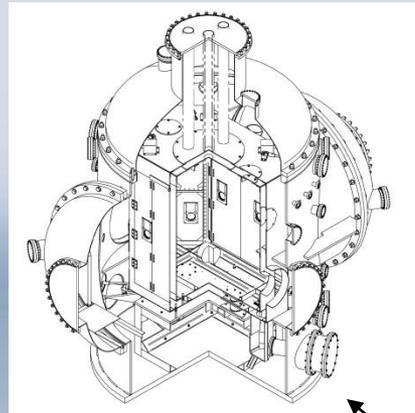
Toshiba Keihin Factory Tube ϕ 1970

Cryostat components

Toshiba Keihin Factory



Ribs inside cryostat



Welding on the connection port



Pipes



Connection port to cryocooler unit

3. Cryocooler unit

1. Outline

Class. Quantum Grav. 21 (2004) S1005–S1008

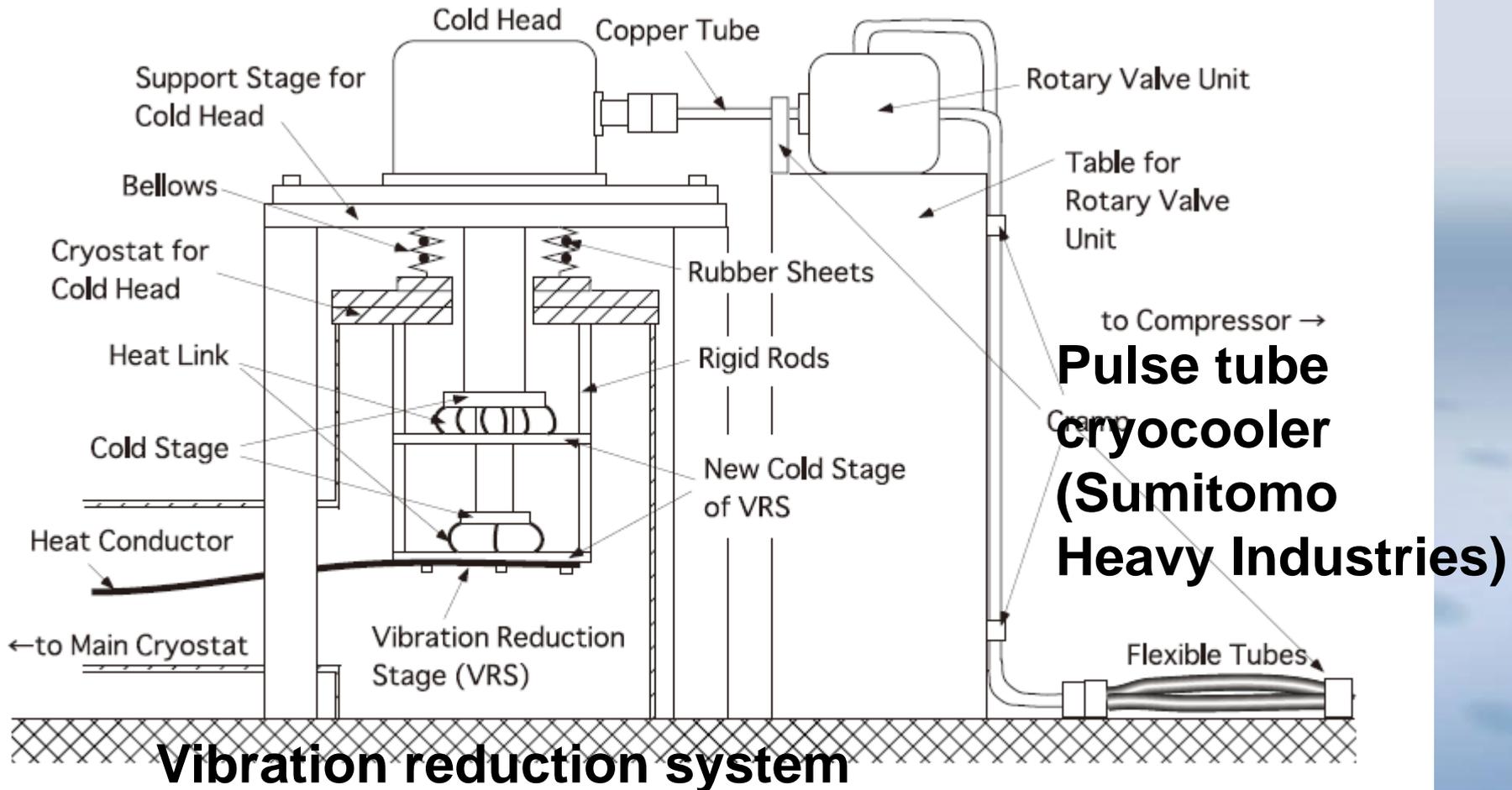
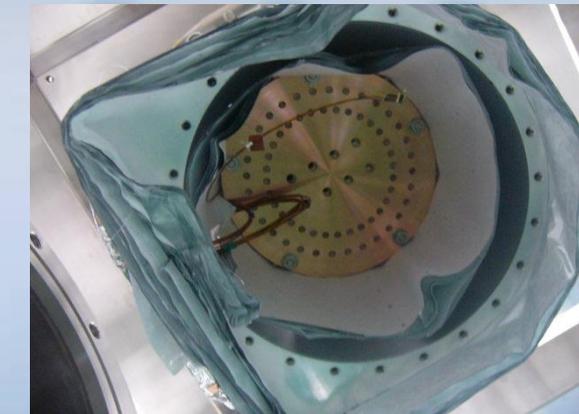
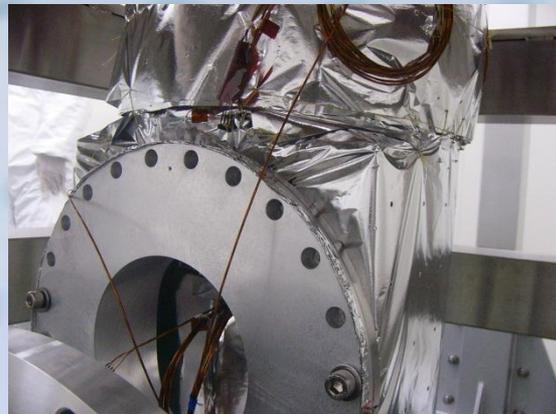
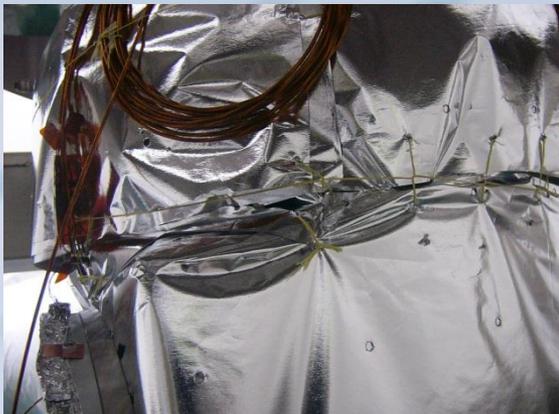
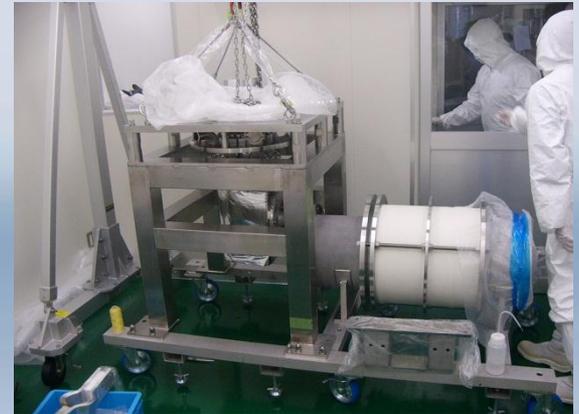


Figure 3. Vibration-reduction system we have been developing for the PT cryocooler.

3. Cryocooler unit

3. Photos

Jecc Torisha Kawagoe Factory

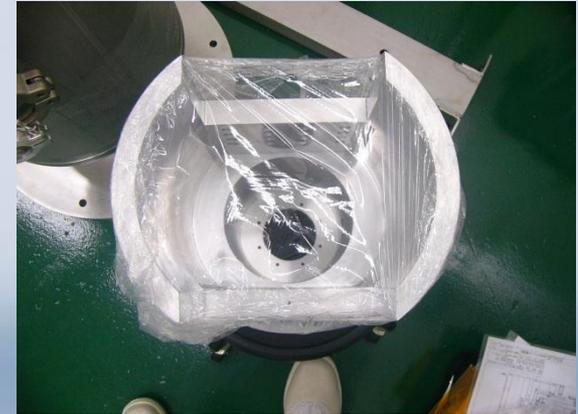
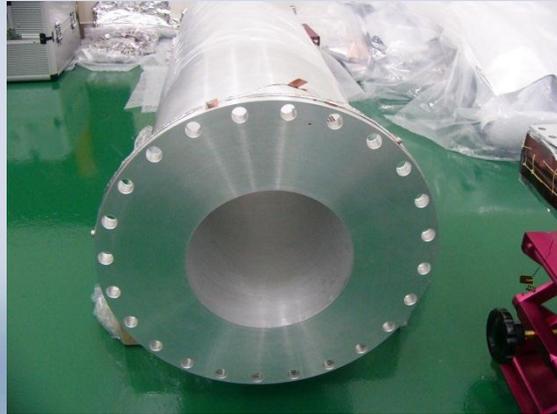


Work progress in clean room with JIS class 7 (US class 10000)

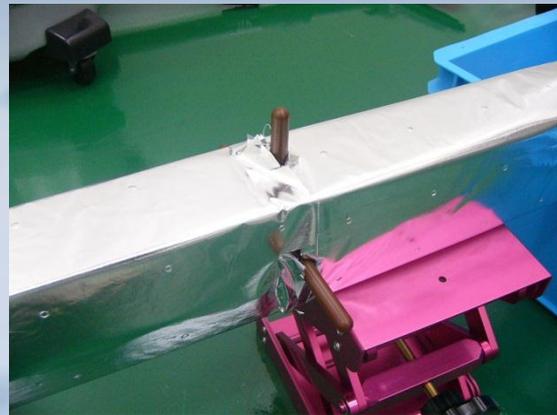
3. Cryocooler unit

3. Photos

Assembling
in Jecc Torisha
Kawagoe factory



80K thermal conductor



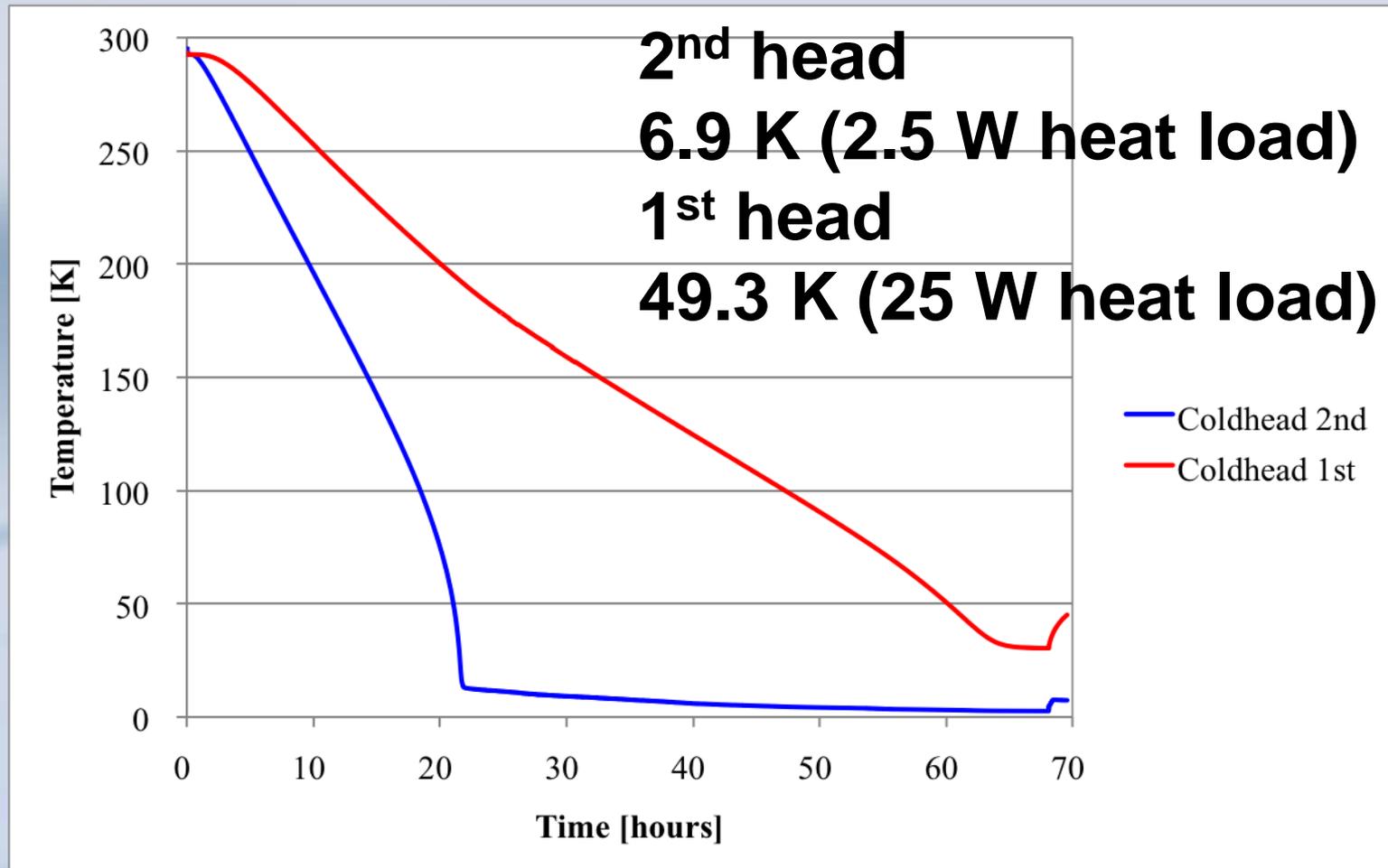
8K thermal conductor



Vespel support rod

3. Cryocooler unit

4. Cooling test : Cryocooler works well.



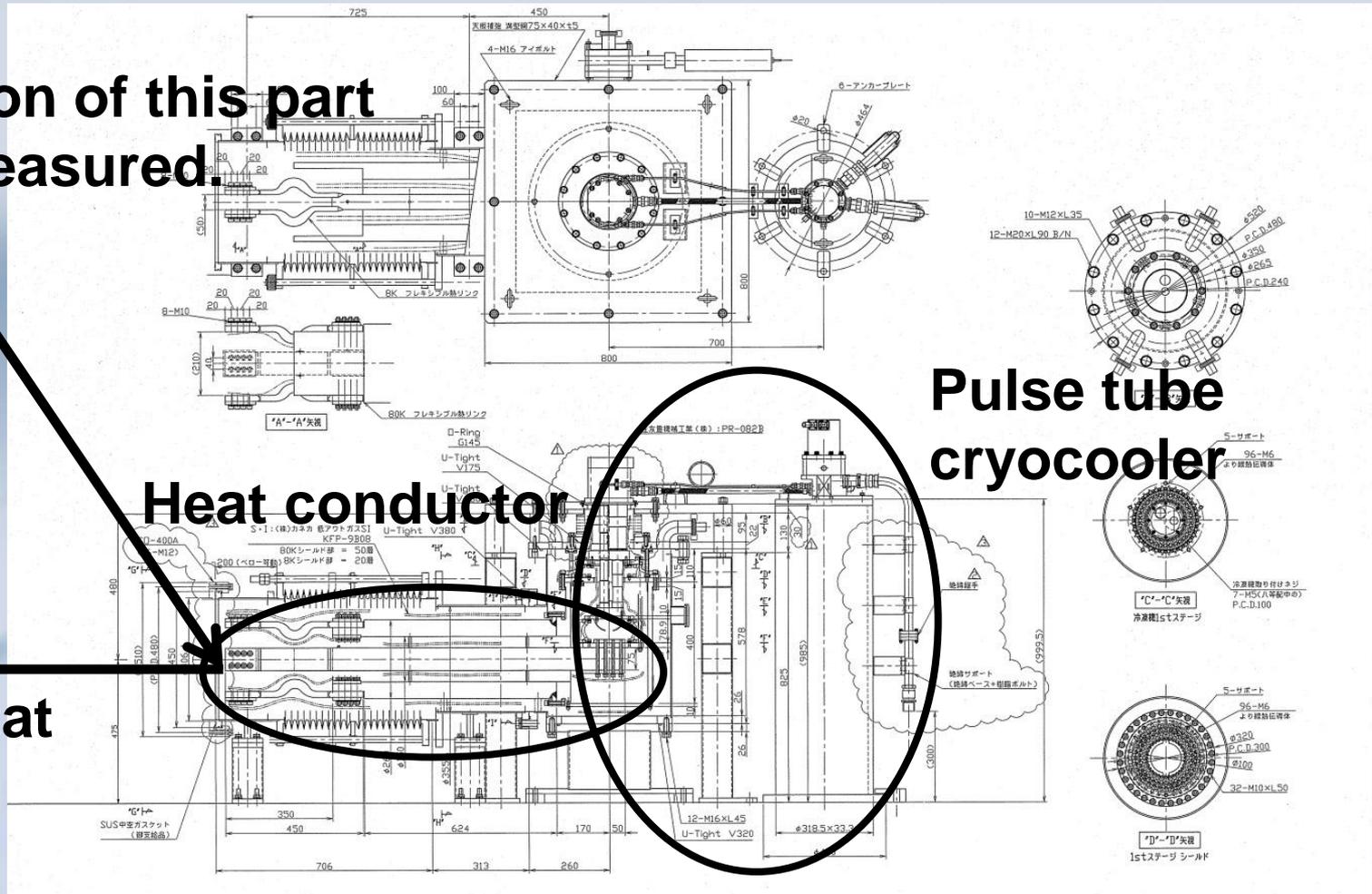
3. Cryocooler unit

5. Vibration measurement

Vibration of this part
was measured.

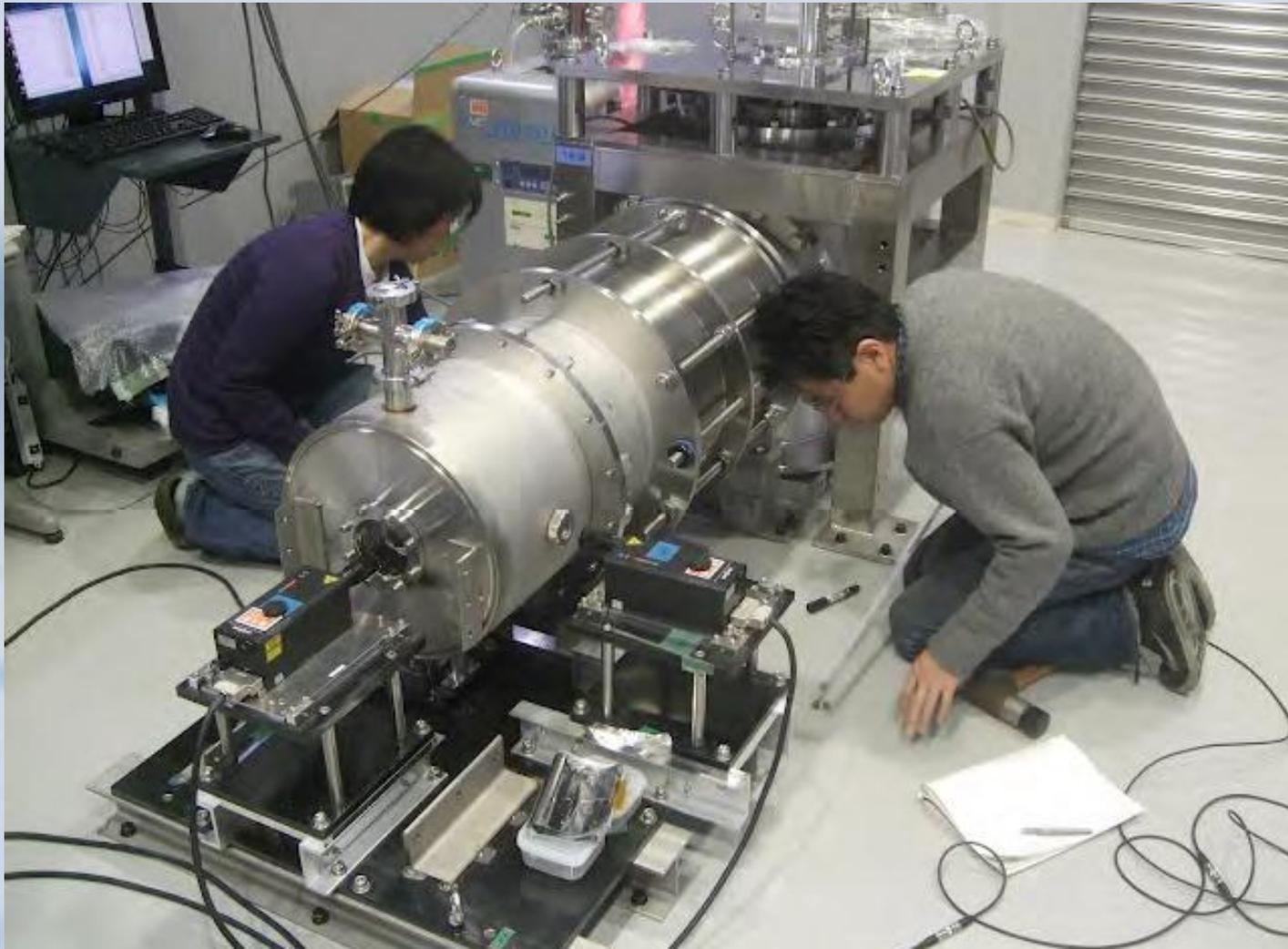
Heat conductor

Cryostat



3. Cryocooler unit

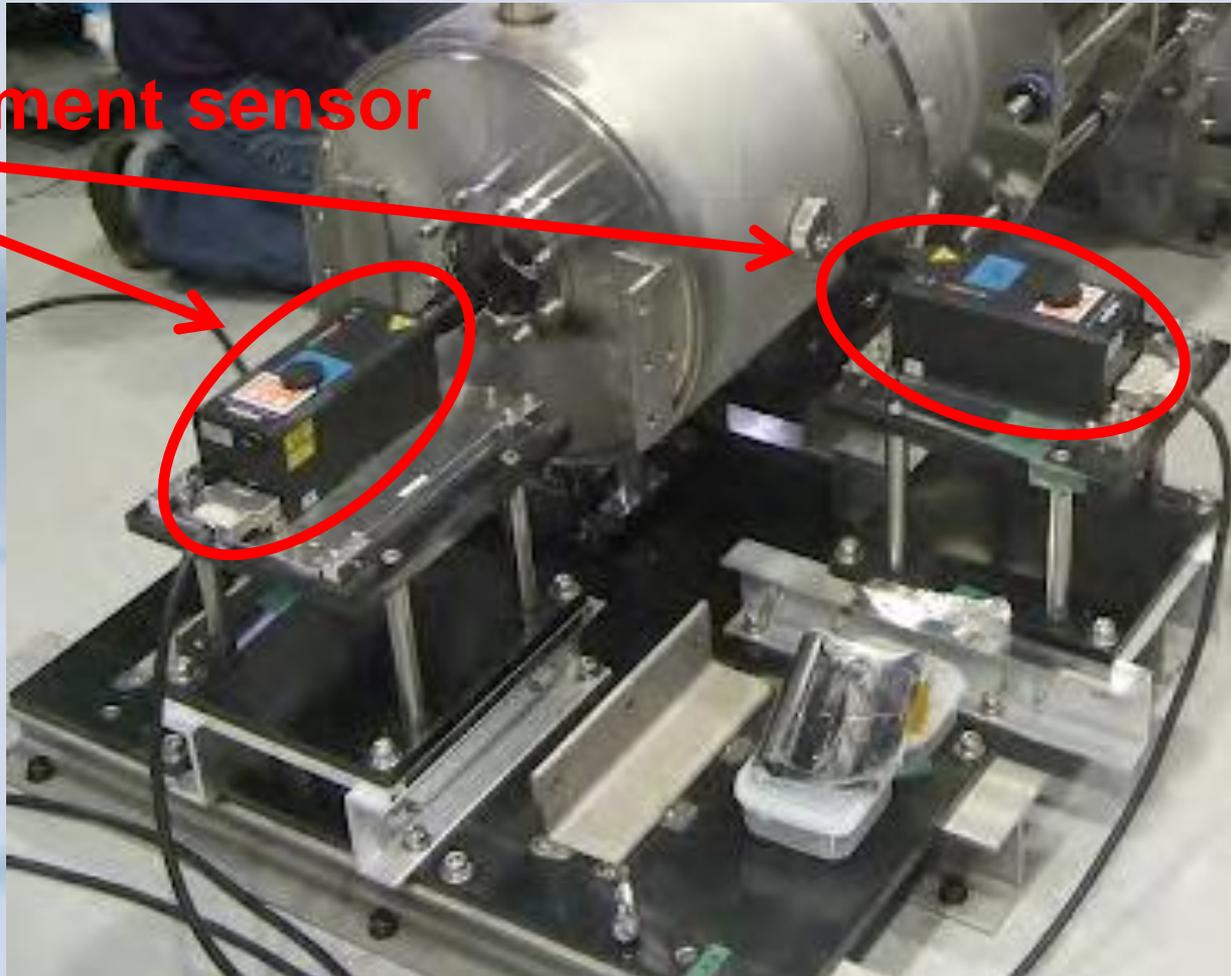
5. Vibration test



3. Cryocooler unit

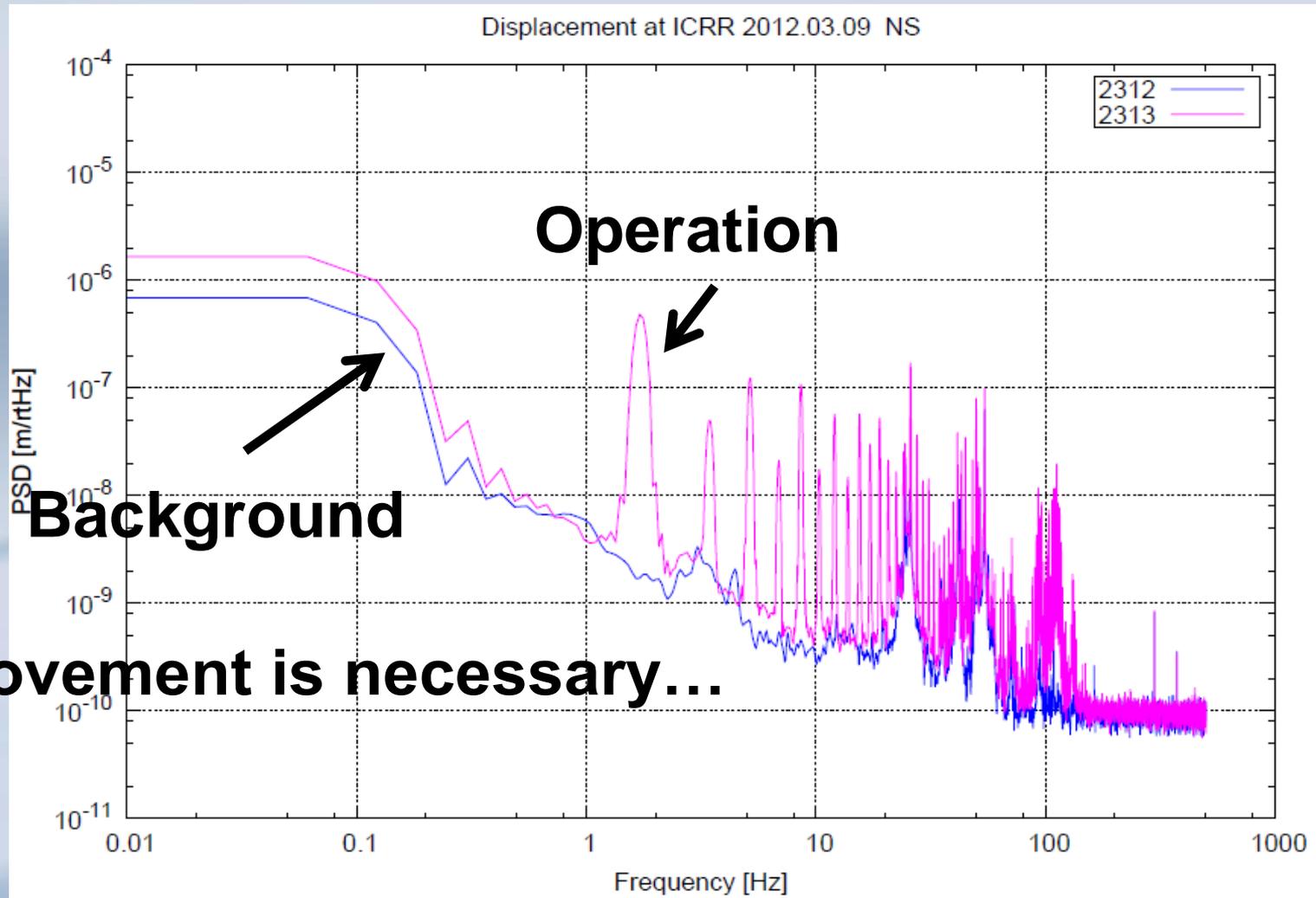
5. Vibration test

Displacement sensor



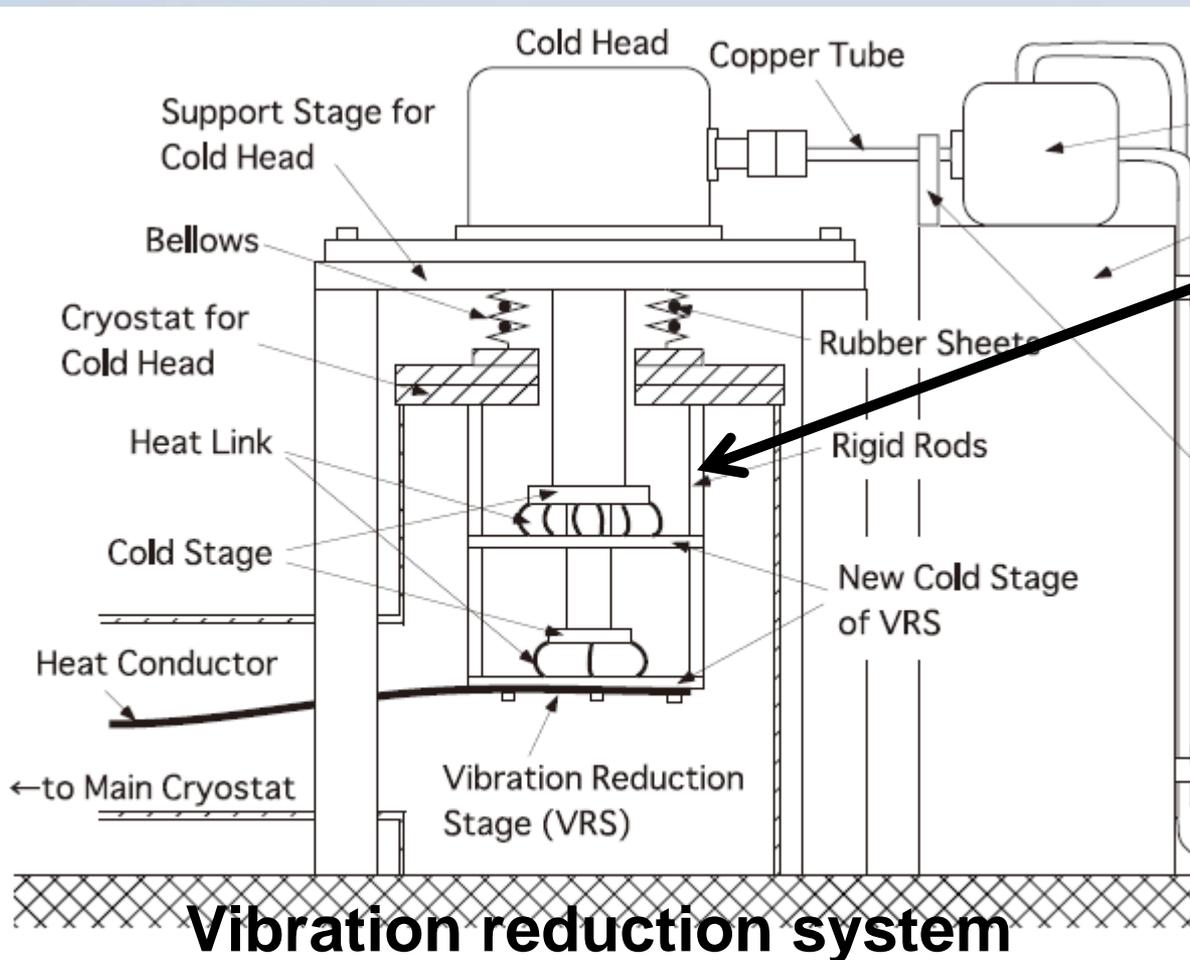
3. Cryocooler unit

5. Vibration test



3. Cryocooler unit

5. Vibration test Class. Quantum Grav. 21 (2004) S1005–S1008



Rigidity of support of stage will be enhanced.

Parts to fix radiation shields will be installed.

Vibration reduction system

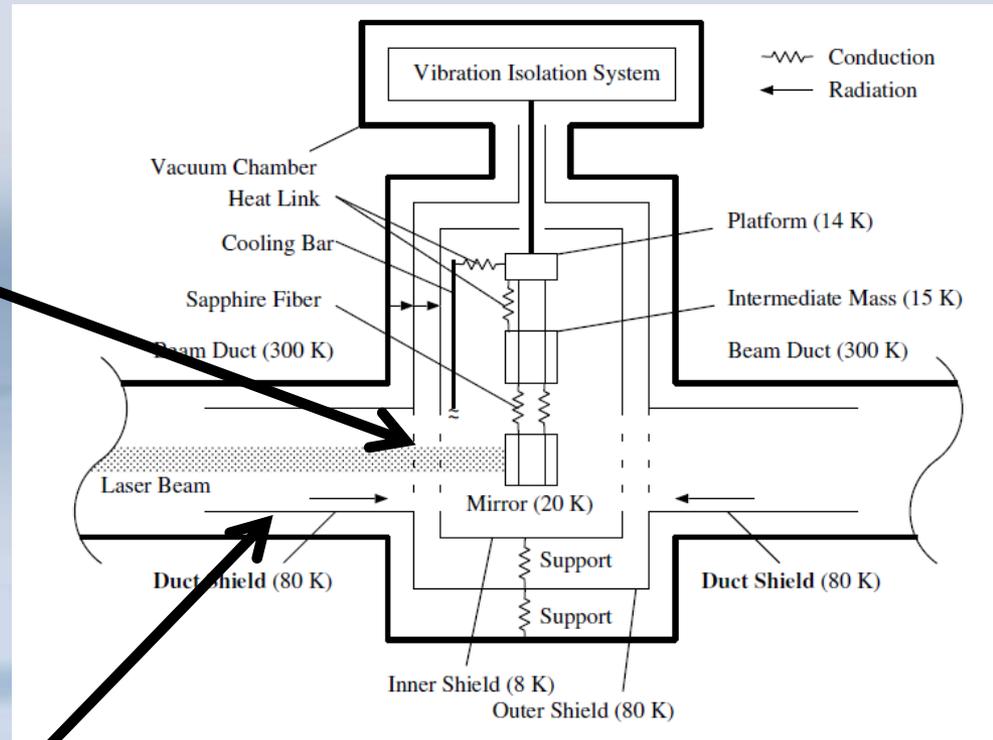
Figure 3. Vibration-reduction system we have been developing for

4. Cryogenic duct

1. Outline

Large hole (almost same as mirror) for laser beam on radiation shield

Huge 300 K radiation (about **20 W**) invades radiation shield.



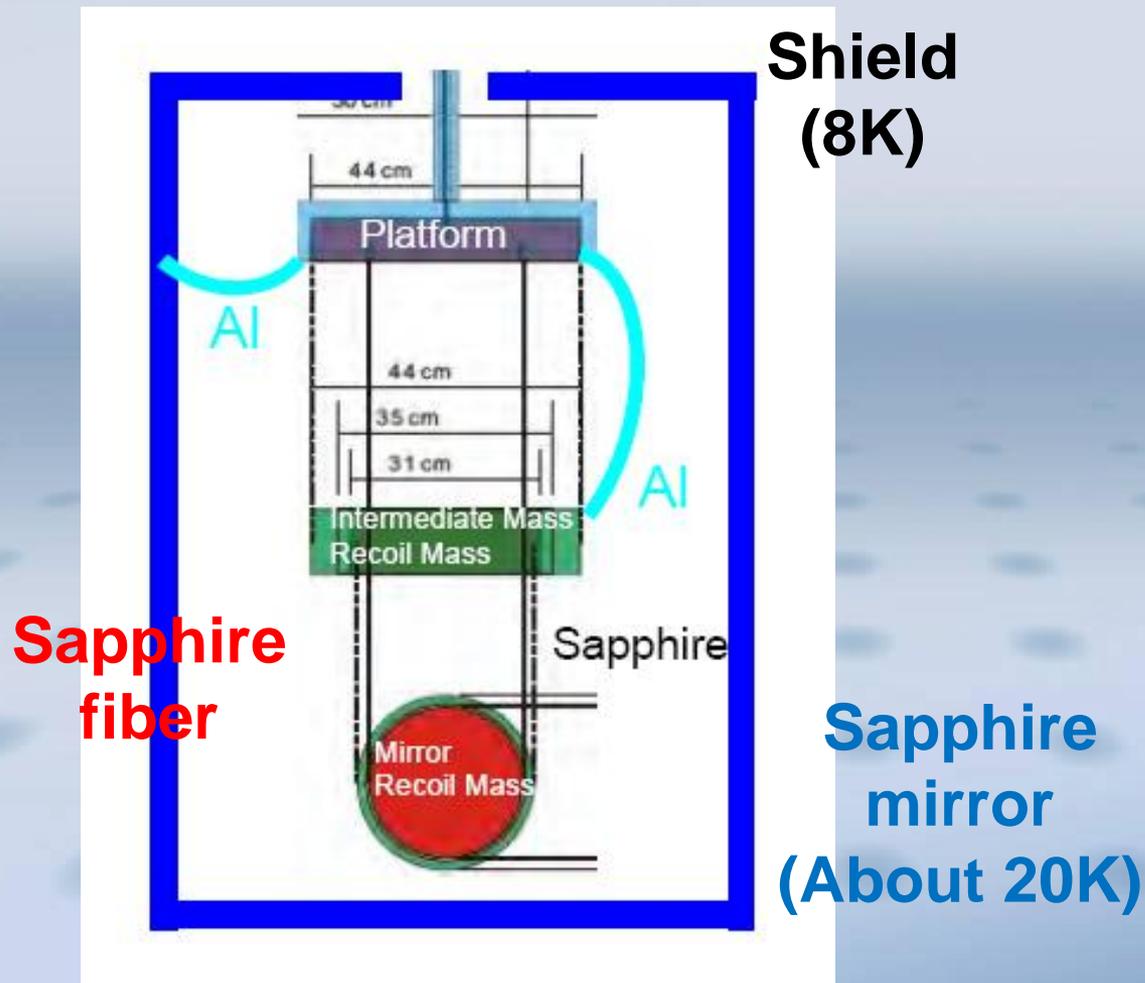
Cryogenic duct (80 K) with baffles are necessary.

T. Tomaru *et al.*, Japanese Journal of Applied Physics 47 (2008) 1771.

T. Tomaru *et al.*, Journal of Physics:Conference Series 122 (2008) 012009.

5. Cryogenic payload

1. Outline



5. Cryogenic payload

2. How to develop

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

in ICRR to check (prototype) payload

1/4 means number of cryocooler, not size.

(a) How to assemble and install

(b) Cooling test

(c) Control and damping at low temperature

(2) Other **R&D**

Sapphire fibers to suspend mirror,

External vibration via heat links

(details are in T. Sukiguchi talk in Tuesday
and K. Yamamoto talk on Thursday)

and so on 28

5. *Cryogenic payload*

3. 1/4 cryostat

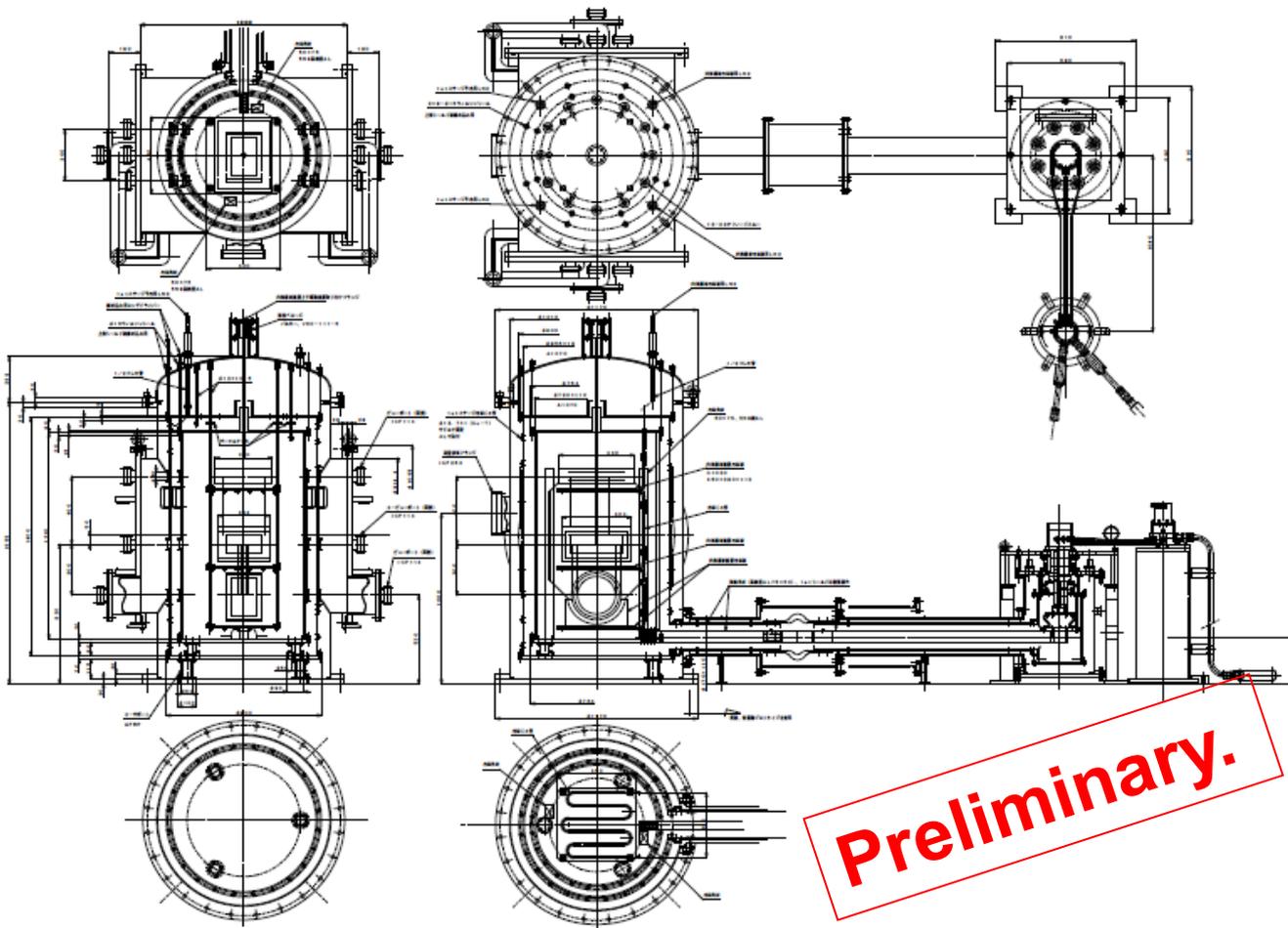
Cryocooler has already arrived at ICRR !



5. Cryogenic payload

3. 1/4 cryostat

Design of 1/4 cryostat is in progress.



6. *ELITES*

**ELITES: ET-LCGT interferometric Telescope
Exchange of Scientists**

**Grant for collaboration about cryogenic
between KAGRA and ET**

European 7th Framework Programme

Marie Curie action (Mar. 2012 - Feb. 2016)

**European people can visit Japan
for KAGRA.**

6. ELiTES

ELiTES consists of four Working Packages.

WP1: Cryogenic payload (E. Majorana)

WP2: Cryogenic mirror (R. Nawrodt)

WP3: Cooling system (K. Somiya)

WP4: Organization (M. Punturo)

6. *ELITES*

Kick off meetings of WP1 and 2 have already been held (WP3 meeting coming soon).

Teleconference every month

General meeting (3rd-4th Oct.) in Tokyo

First visitors (Ettore Majorana and Luca Naticchioni) have already arrived on April !

Informal meetings are during this GWADW !

First 'quasi' ELiTES face to face meeting

14 May 2012



7. Future plan

Mar. 2013: **All cryostats and all cryocooler units are assembled.**

1/4 cryostat arrives.

Apr. 2013 - Sep. 2014: **Experiment** of 1/4 prototype

Apr. 2014 - Sep. 2014 : **Installation** of **cryostats** and **cryocoolers** in **Kamioka mine**

Jul. 2014 - Mar. 2015 : **Procurement** for **payload**

Jul. 2015 - Dec. 2016: **Installation** and **test** of **cryogenic payload** in **Kamioka mine**

Sep. 2017 - Mar. 2018 : **Cryogenic interferometer operation**

Apr. 2018 - : **Tuning and observation**

8. *Summary*

Cryostats and **cryocooler units** are **assembled** and **tested now** (until Mar. 2013).

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

1/4 cryostat : Prototype test

Payload should be prepared by Mar. 2015.

ELITES : Collaboration with **ET** (until Feb. 2016).

We **proceed** with **construction** of **first km-scale**
cryogenic interferometer vividly.

Thank you for your attention !

2. Cryostat

3. Photos

Ribs inside cryostat



Pipes



Main body ($\Phi 2.4\text{m}$, H3.8m)

Welding on the connection port



Connection port to cryo-cooler unit



4. *Cryogenic payload*

4. 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