Current status of KAGRA Cryogenic

K. Yamamoto and KAGRA collaboration

Institute for Cosmic Ray Research
the University of Tokyo

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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 payload*
5. *ELiTES*
6. *Future Plan*
7. *Summary*

1. Introduction

KAGRA (previously known as: LCGT)

2nd generation interferometer in Japan

Key feature of KAGRA project

Cryogenic system : Reduction of thermal noise

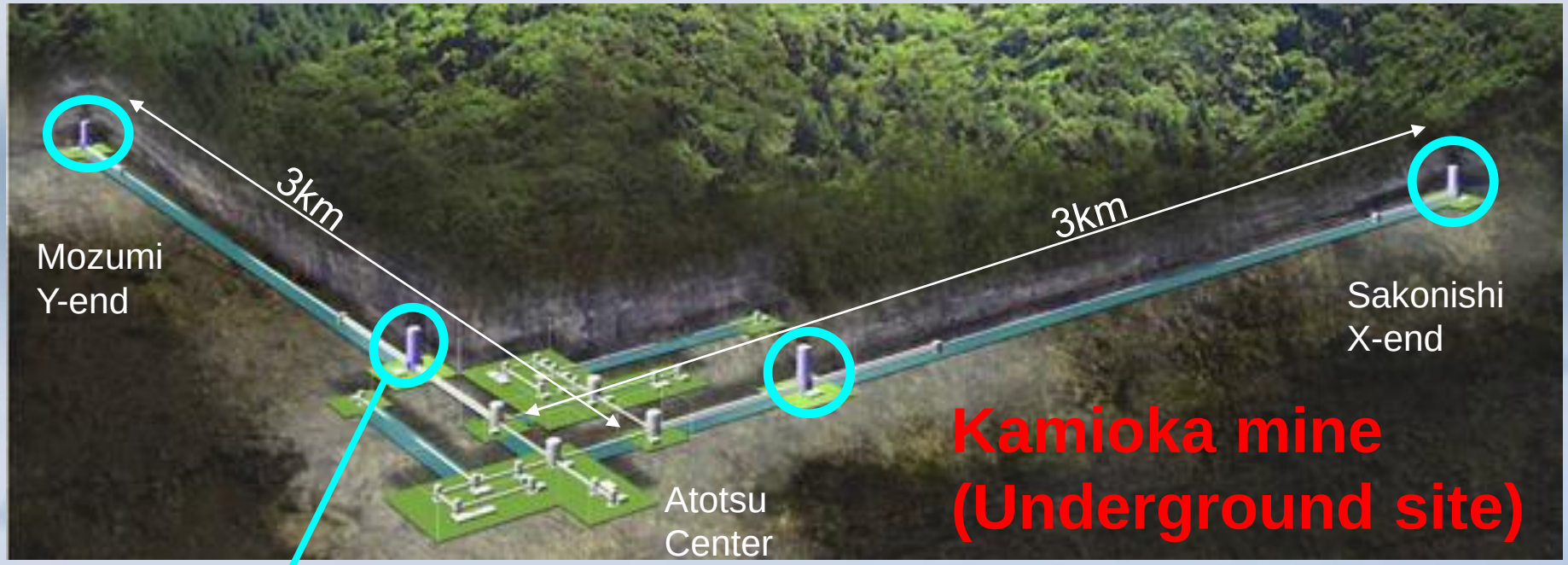
I will explain the progress for cryogenic system in the last one year.

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

1. Introduction

Outline of cryostat and cryocoolers

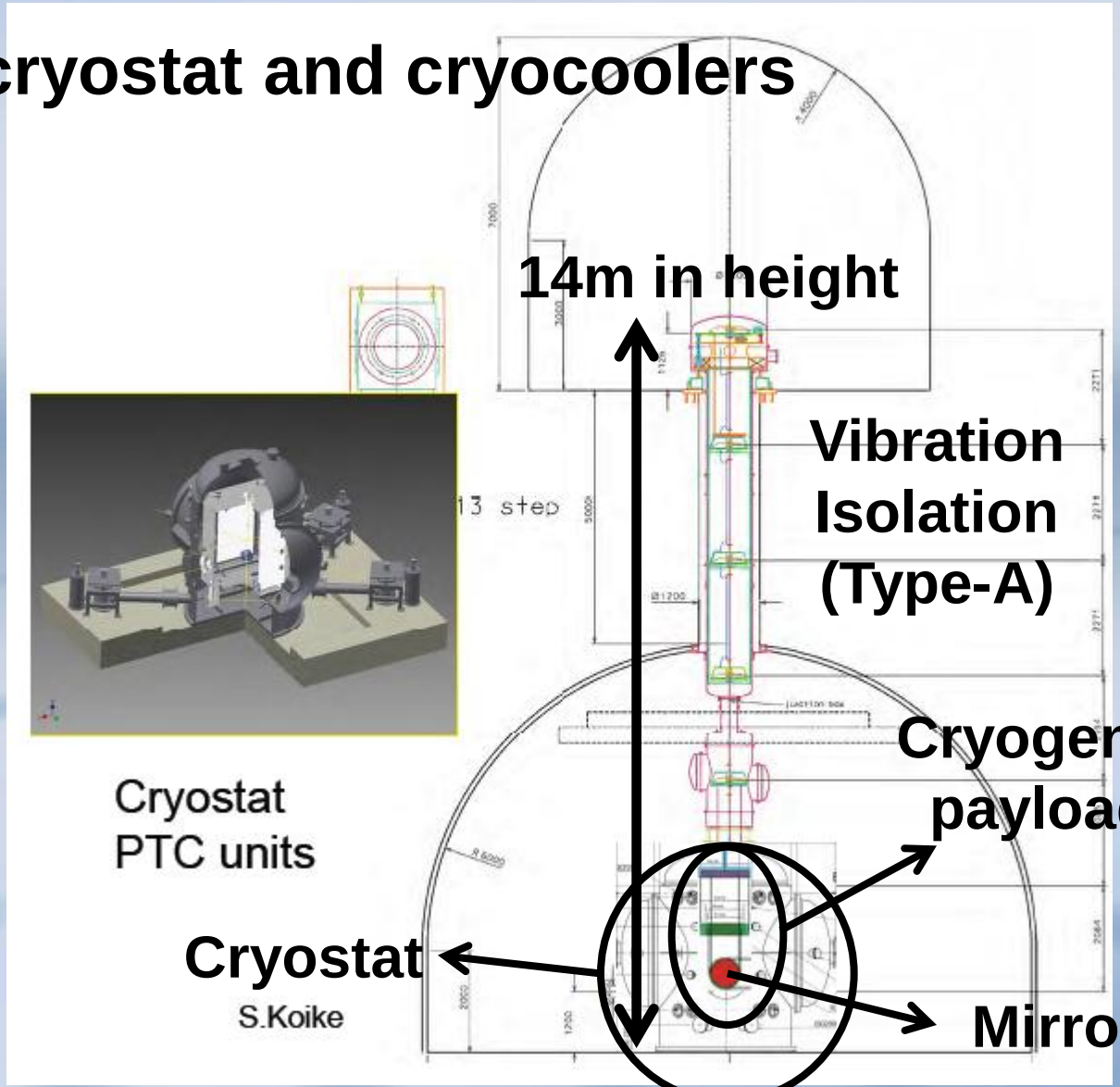
Four mirrors of arm cavity will be cooled.



Vibration isolation system, Cryostat, Cryocooler, Cryogenic payload

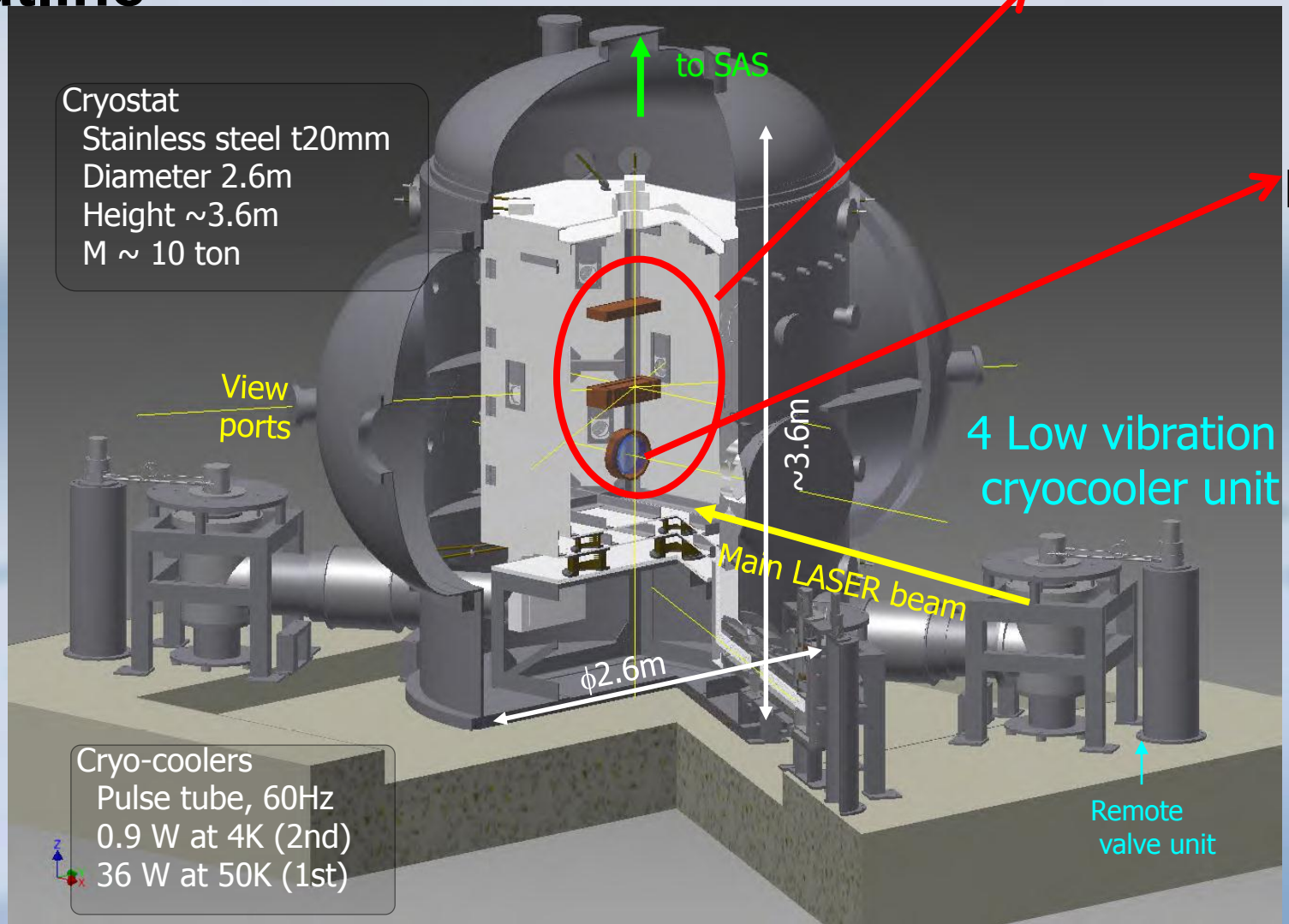
1. Introduction

Outline of cryostat and cryocoolers



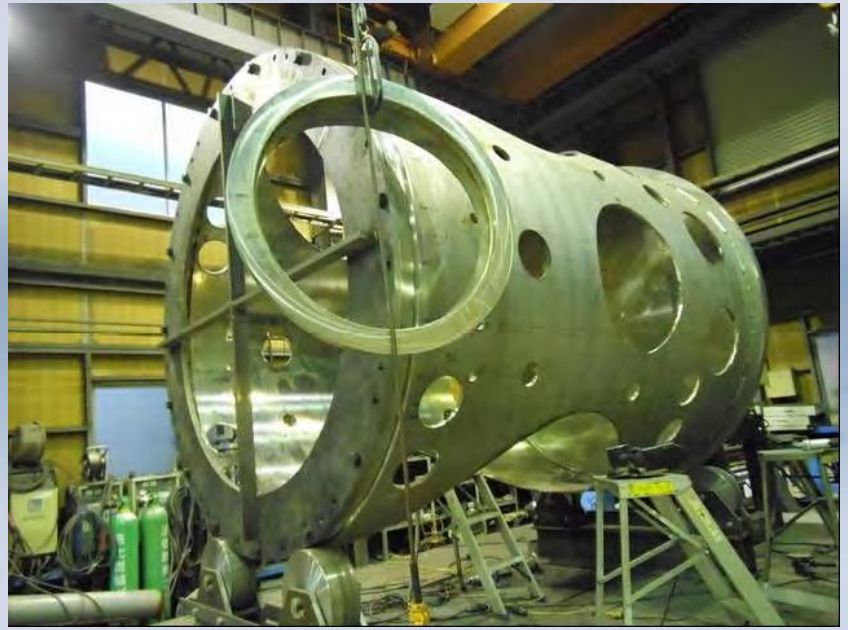
2. Cryostat

1. Outline



2. Cryostat

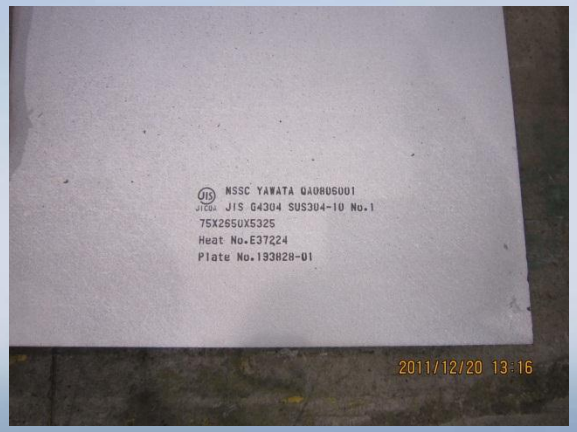
2. Photos (Main body)



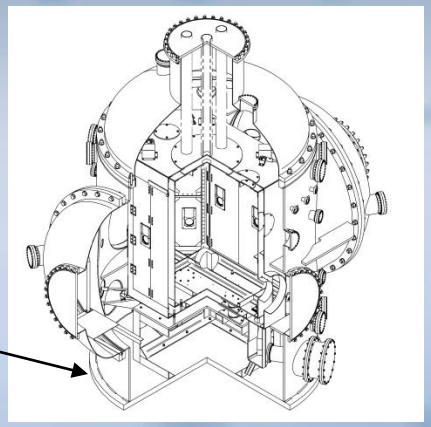
Main body (Φ2.4m, H3.8m)

at Toshiba Keihin Factory

Cryostat Bottom plate SUS 304 t70

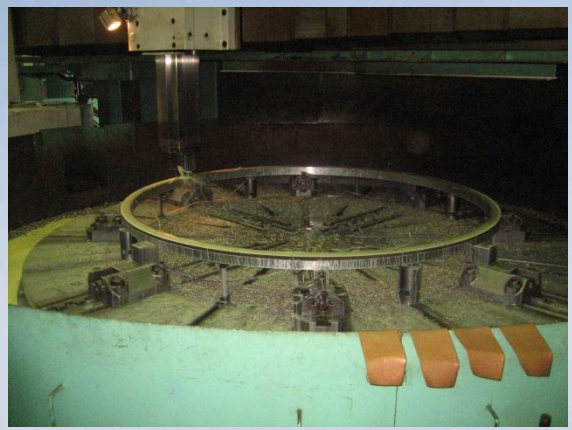


Daiwa Shearing Kasuga Factory



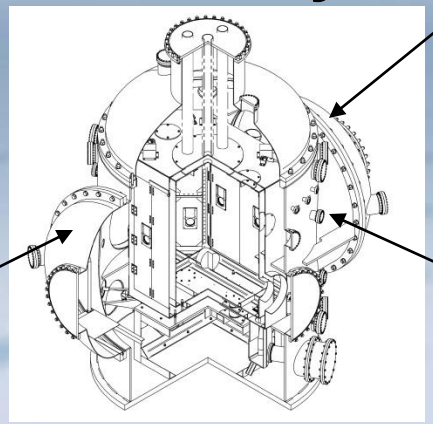
Toshiba Keihin Factory

Cryostat Service port flange, side cap and tube



Shimoda Flange Aioi Factory

Flange ϕ2200



Side cap ϕ1970

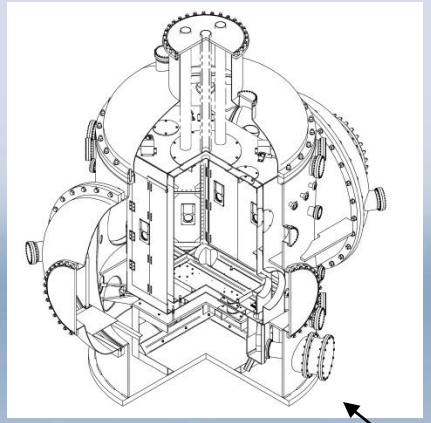
Toshiba Keihin Factory

Tube ϕ1970

Cryostat components

Toshiba Keihin Factory

Ribs inside cryostat



Welding
on the connection port

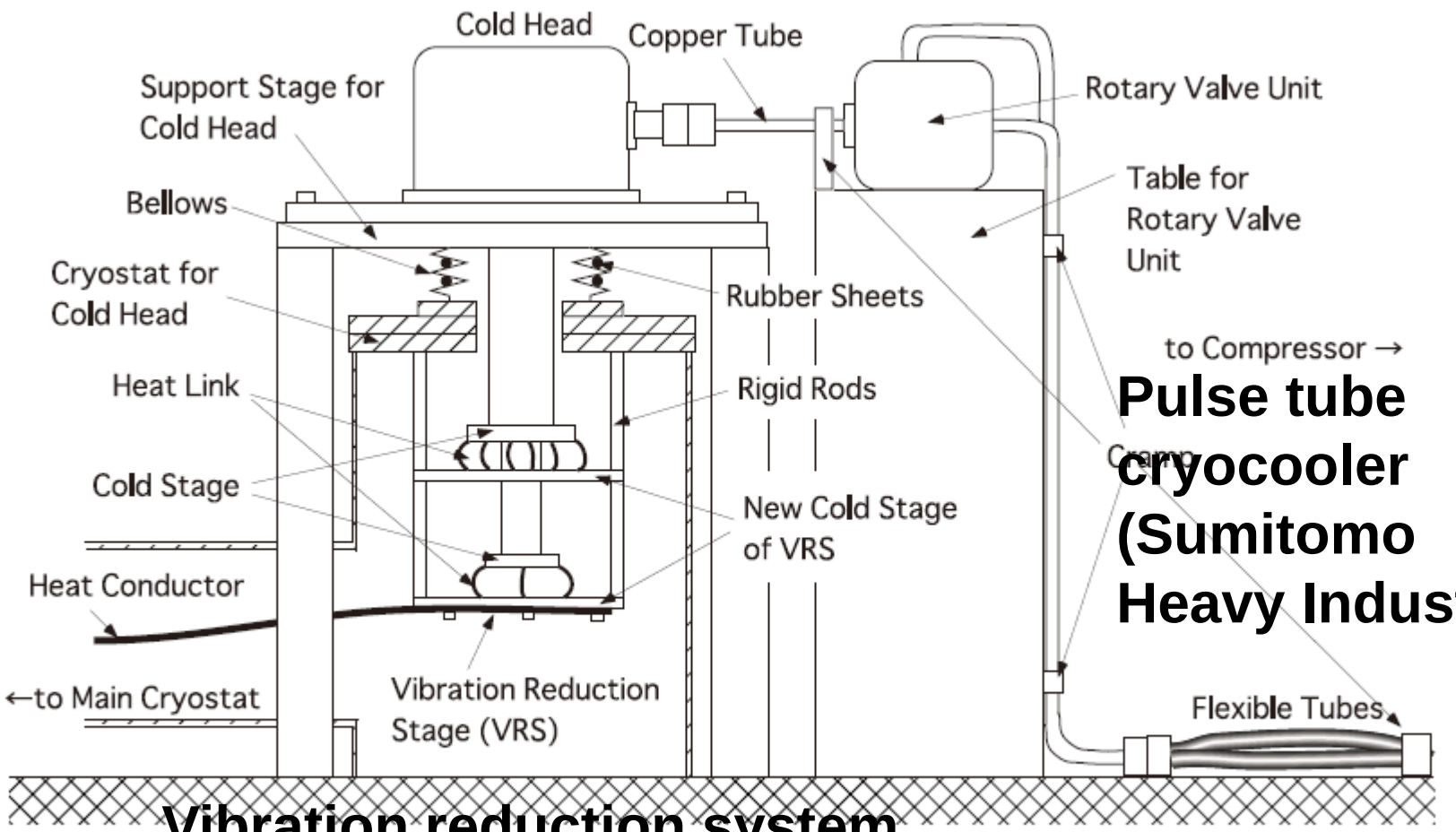
Pipes

Connection port to cryocooler unit

3. Cryocooler unit

1. Outline

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



Pulse tube cryocooler (Sumitomo Heavy Industries)

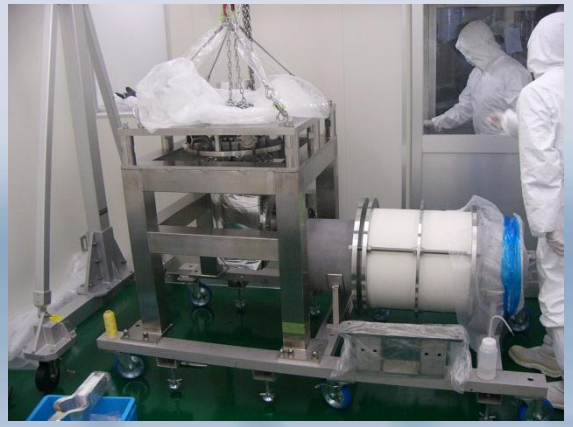
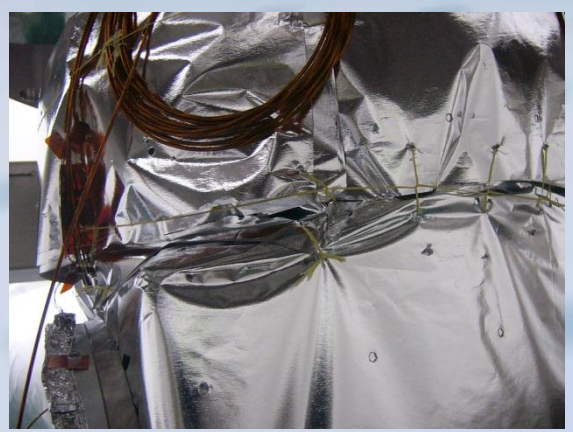
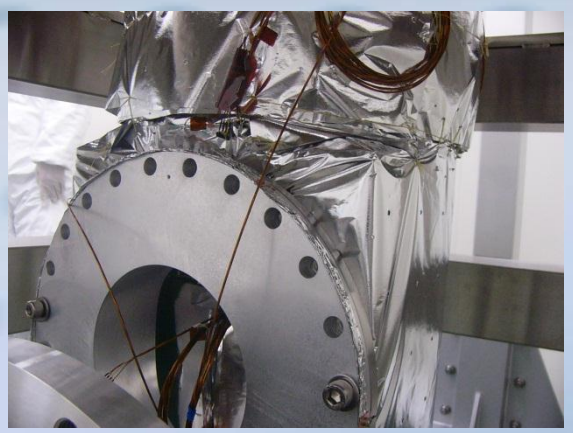
Vibration reduction system

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

3. Cryocooler unit

2. Photos at Jecc Torisha Kawagoe factory



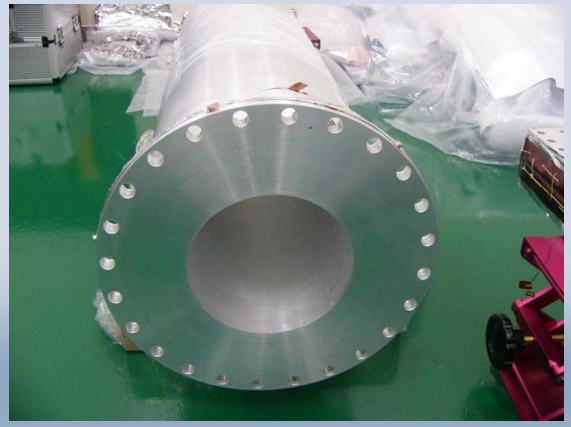




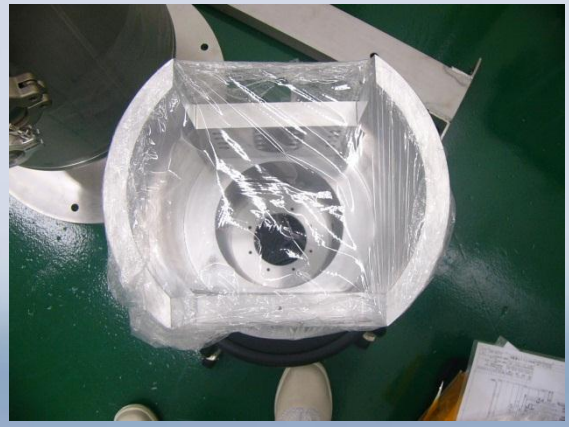

Work progress in clean room with JIS class 7 (US class 10000)

3. Cryocooler unit

3. Photos

Assembling
in Jecc Torisha
Kawagoe factory





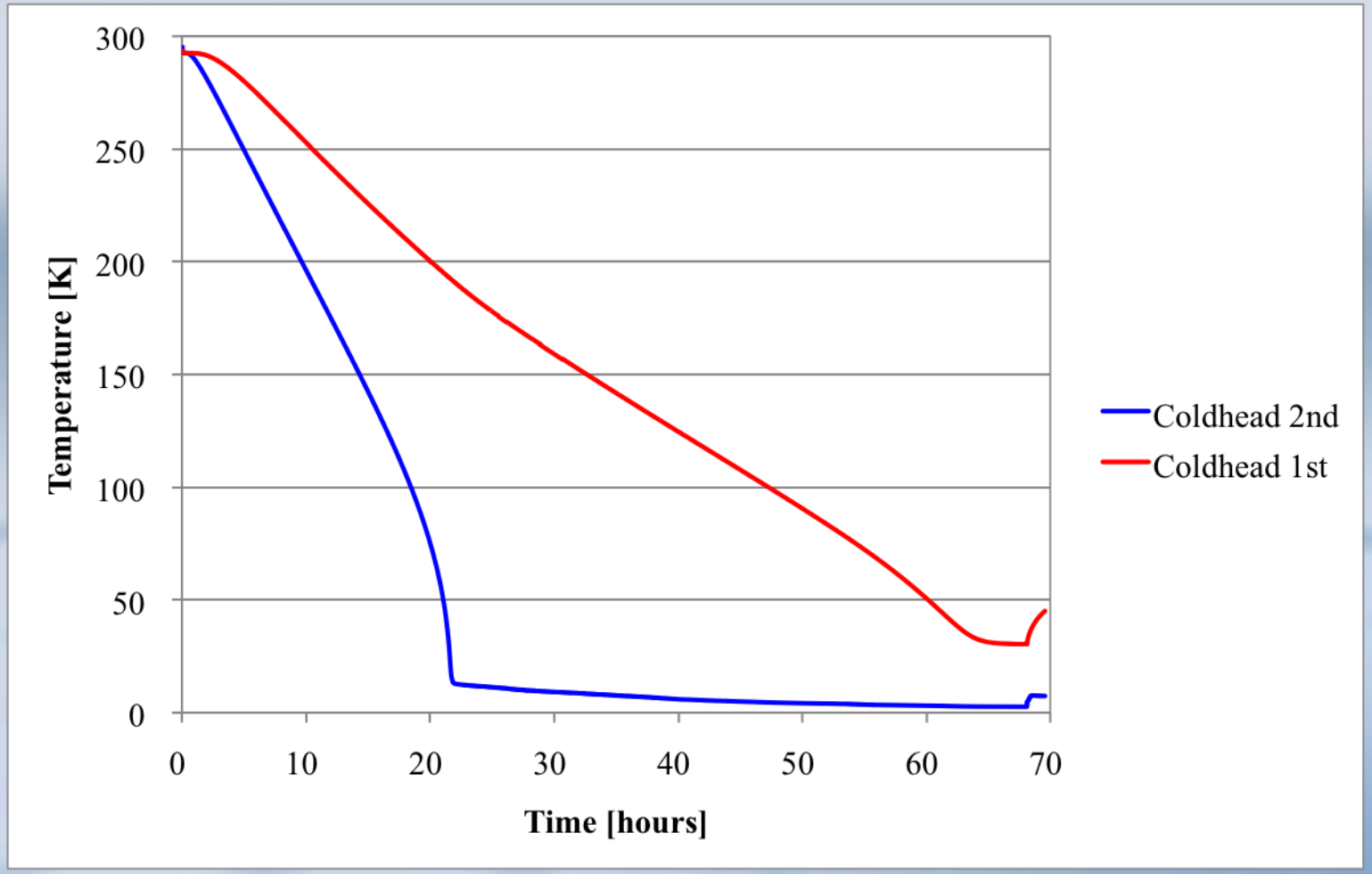
80K thermal conductor

8K thermal conductor

Vespel support rod

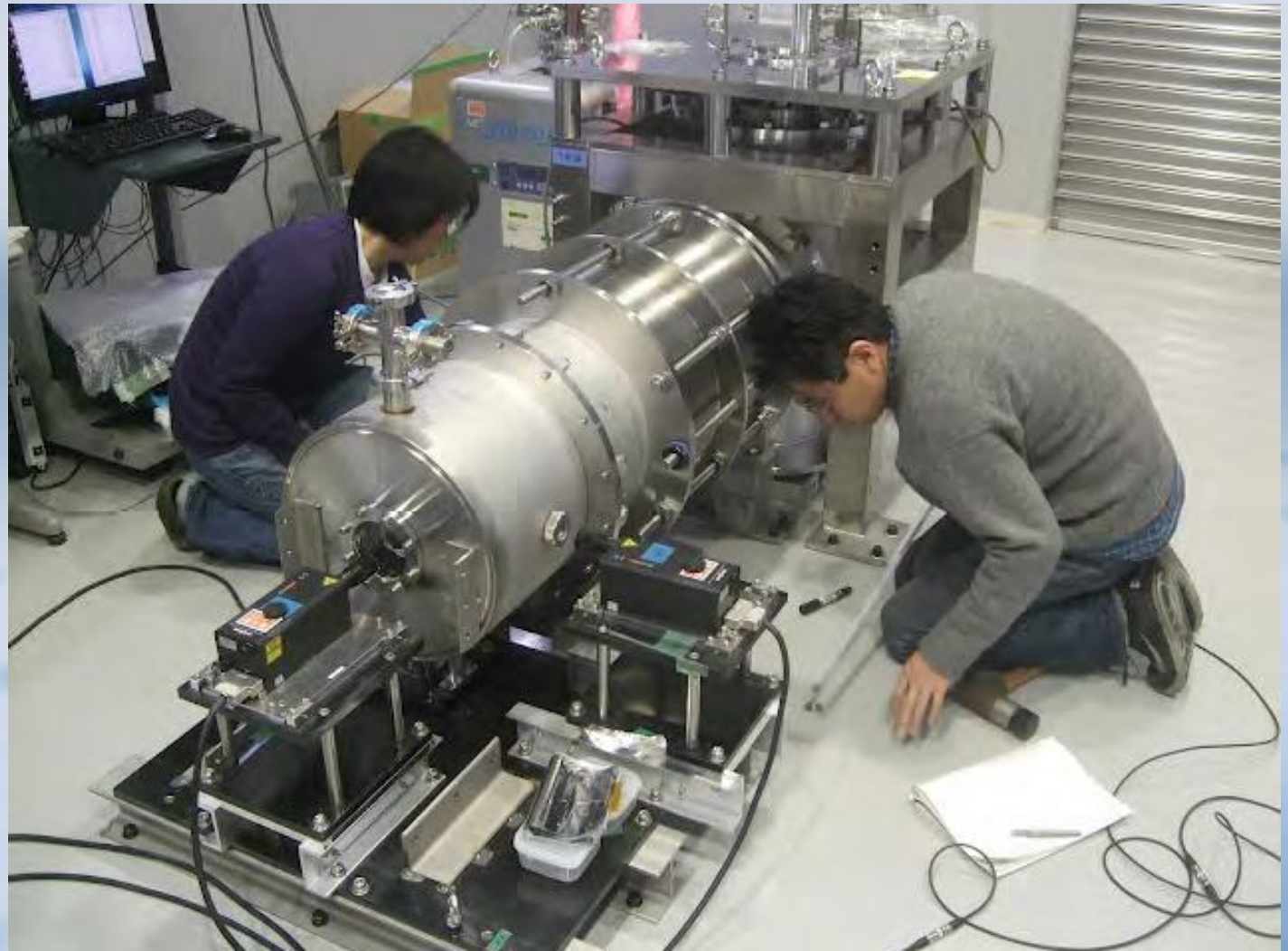
3. Cryocooler unit

4. Cooling test : Cryocooler works well.



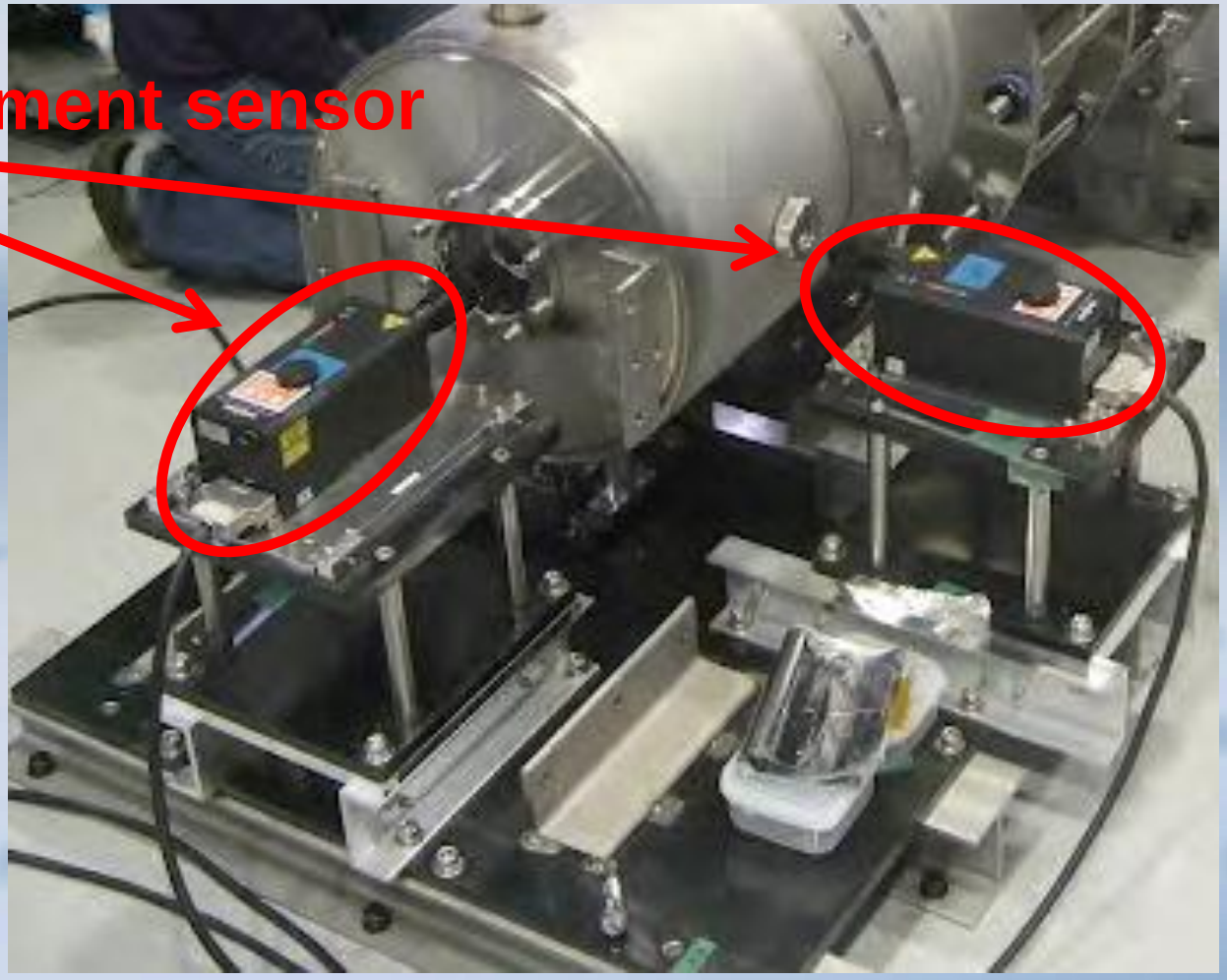
3. Cryocooler unit

5. Vibration test



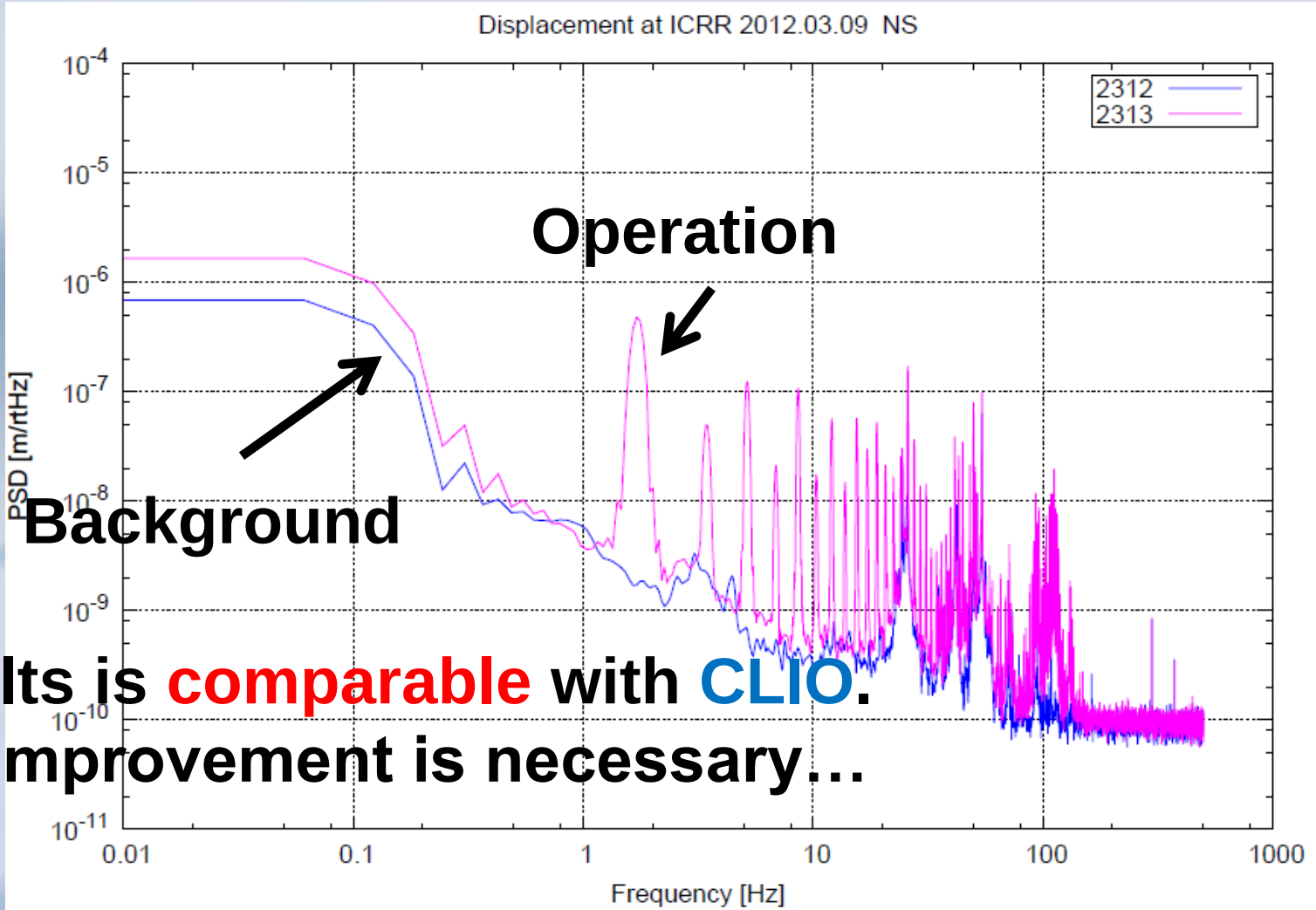
3. Cryocooler unit

5. Vibration test



3. Cryocooler unit

5. Vibration test

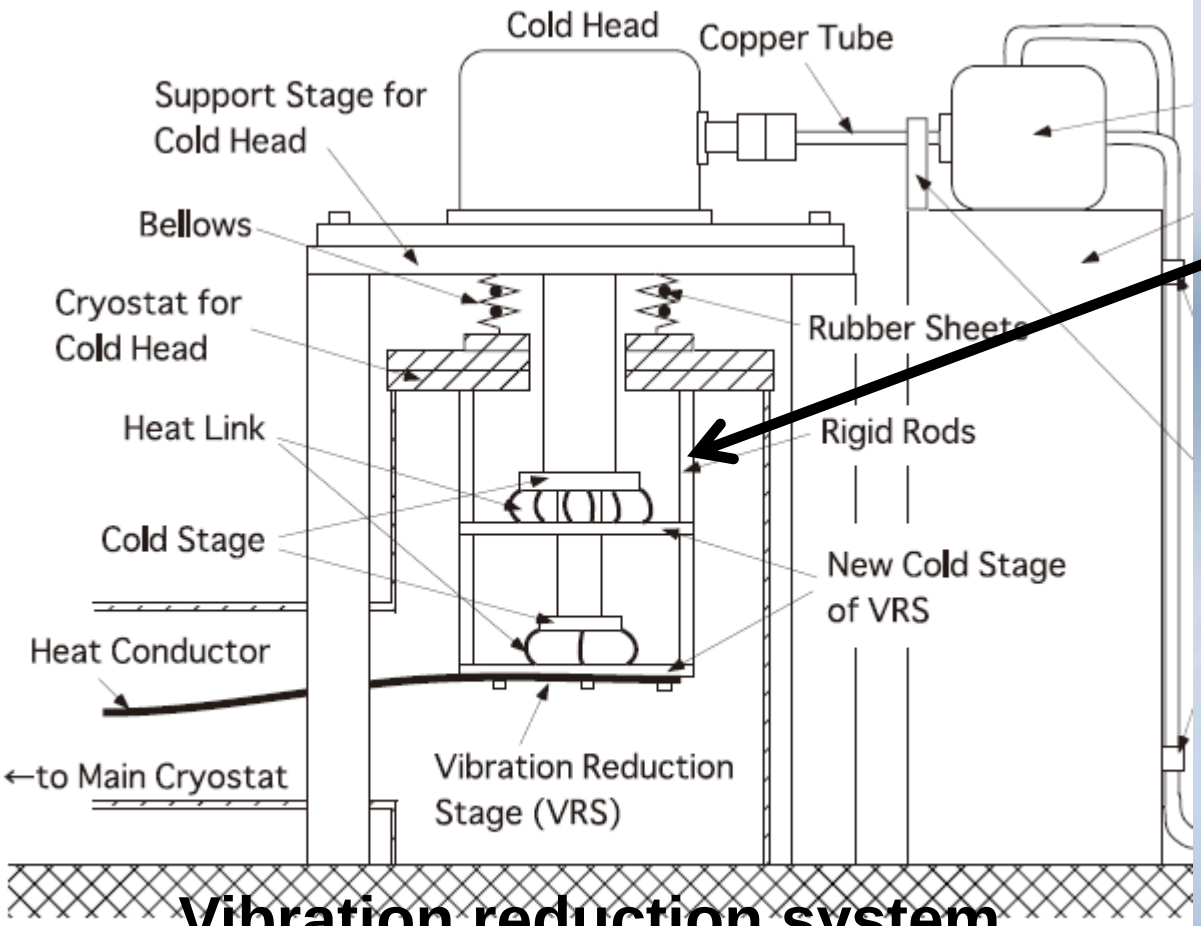


Results is comparable with CLIO.
But, improvement is necessary…

3. Cryocooler unit

5. Vibration test

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



Vibration reduction system

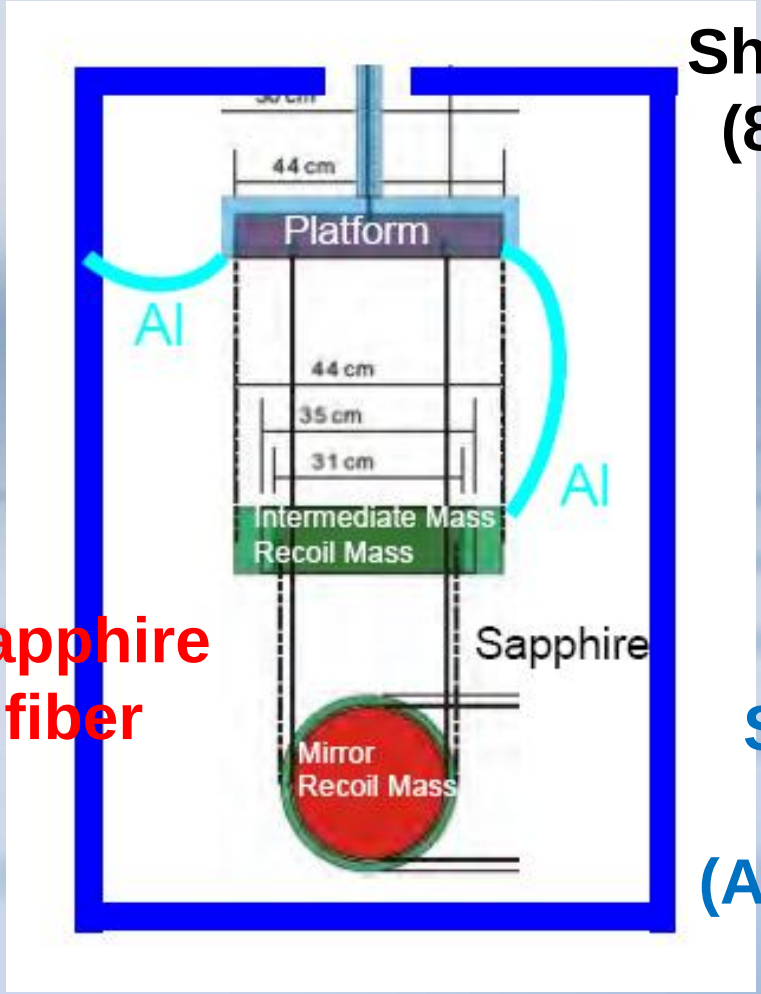
Figure 3. Vibration-reduction system we have been developing for

Rigidity of stage will be enhanced.

Parts to fix radiation shields will be installed.

4. Cryogenic payload

1. Outline



4. 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

(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

4. Cryogenic payload

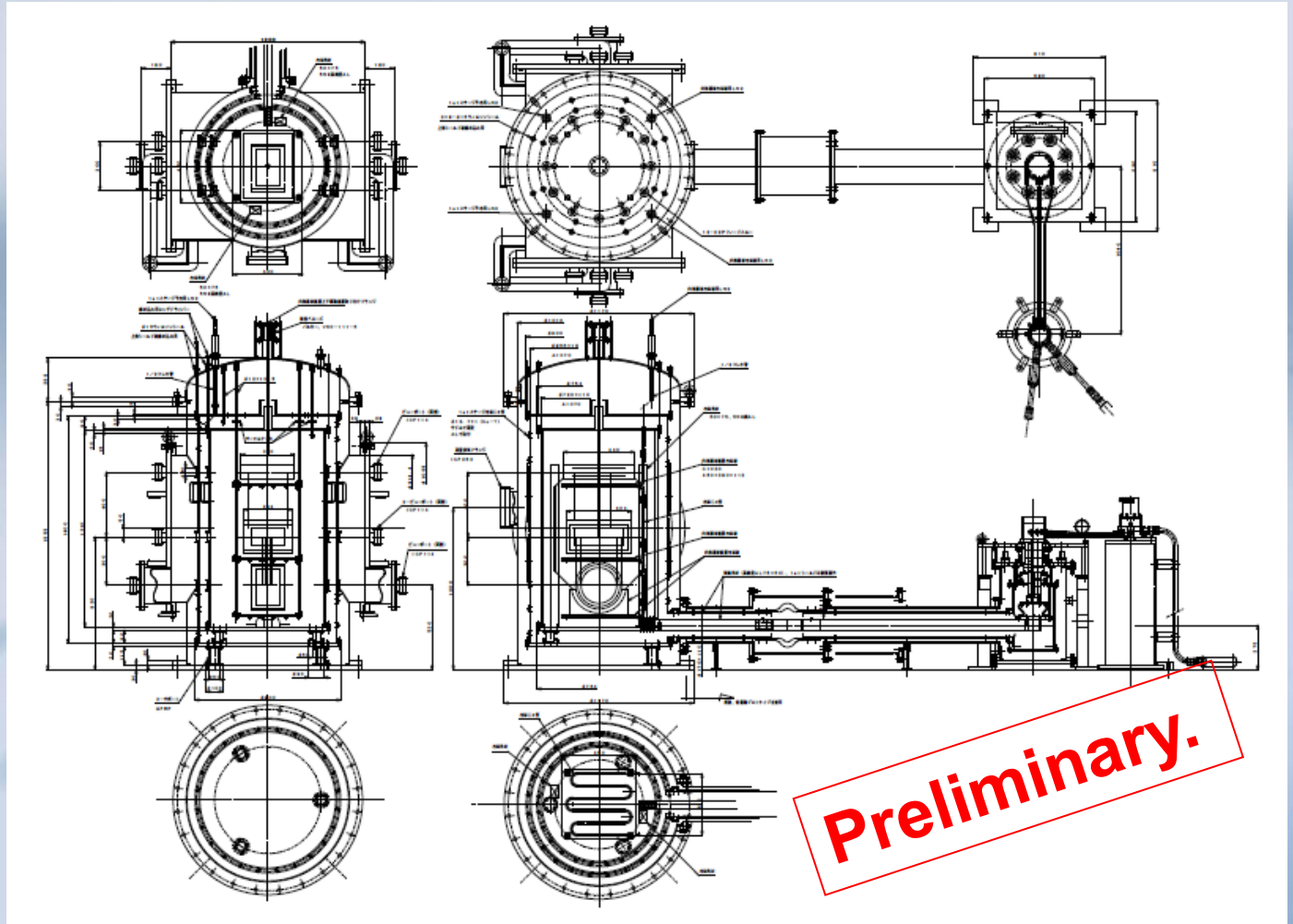
3. 1/4 cryostat

Cryocooler has already arrived at ICRR !

4. Cryogenic payload

3. 1/4 cryostat

Design of 1/4 cryostat is in progress.



5. 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.

5. ELiTES

ELiTES consists of four Working Packages.

WP1: Cryogenic payload (E. Majorana)

WP2: Cryogenic mirror (R. Nawrodt)

WP3: Cooling system (K. Somiya)

WP4: Organization

5. ELiTES

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

Teleconference every month

General meetings in Japan and Europe

First visitor from Europe : This autumn

Informal meetings are during this GWADW !

6. Future plan

Mar. 2013: All cryostats and all cryostats 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

7. 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.

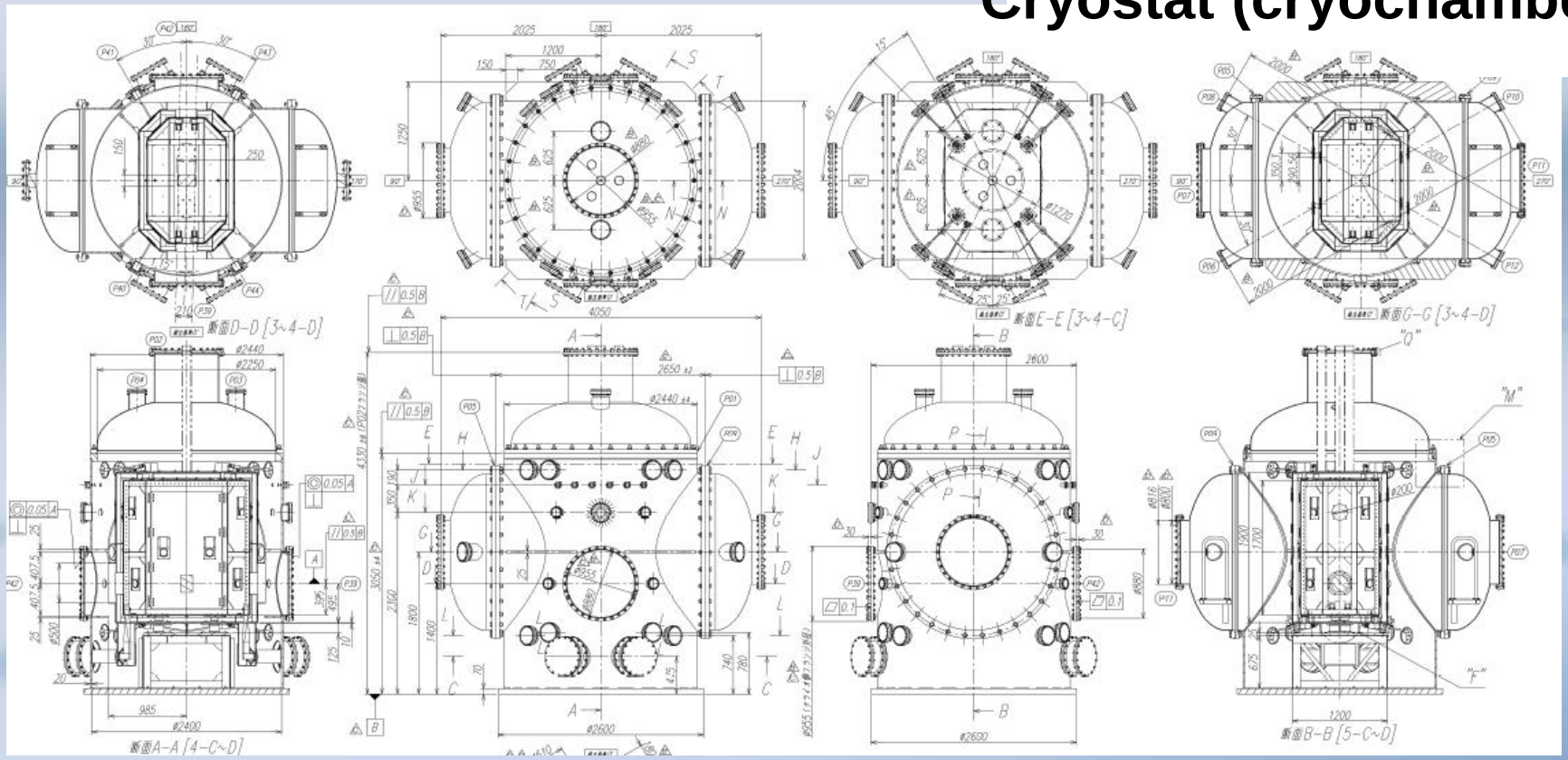
Thank you for your attention !

2. Cryostat

2. Drawing by Toshiba

Toshiba starts to make our cryostat.

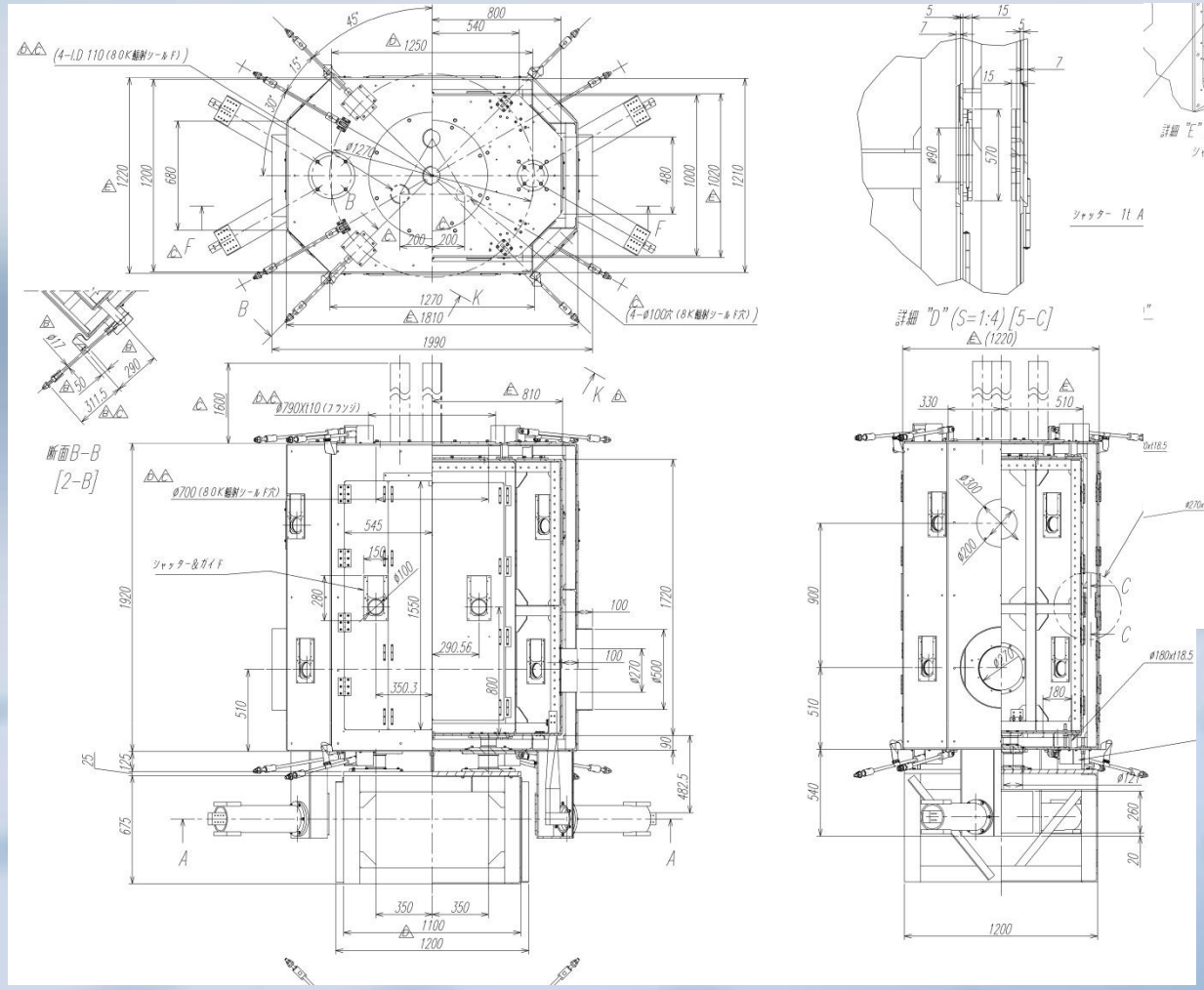
Cryostat (cryochamber)

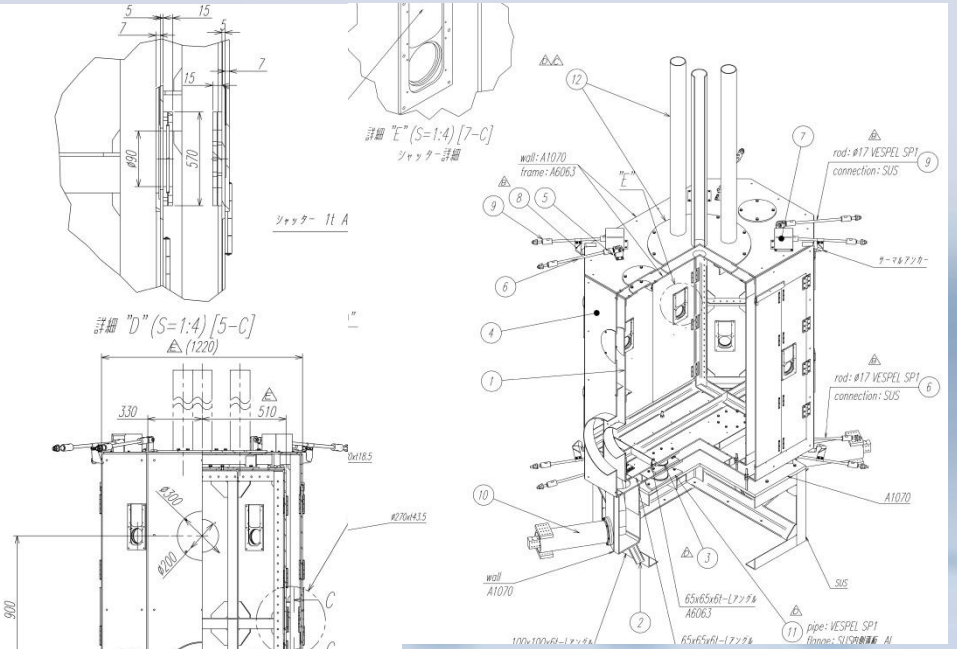


2. Cryostat

2. Drawing by Toshiba

Cryostat (radiation shields)





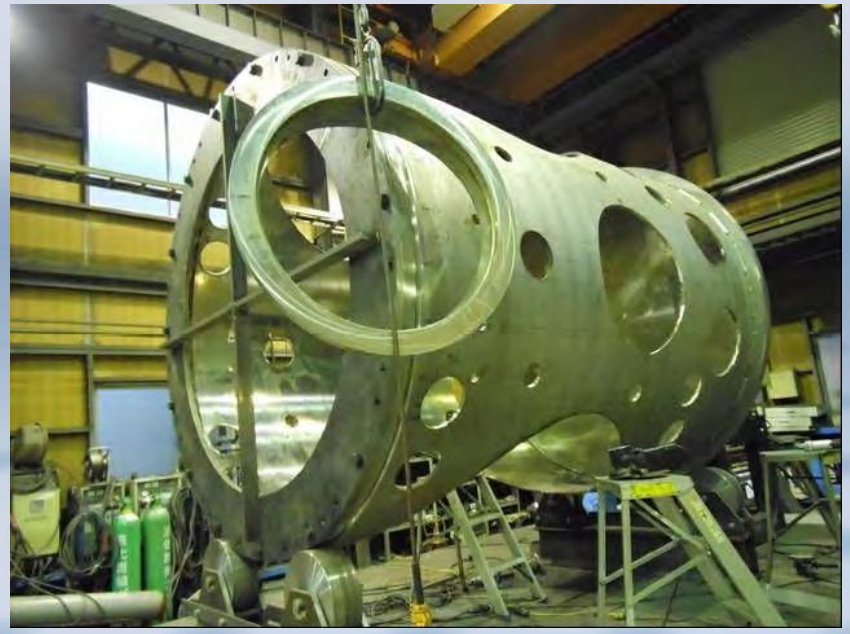
Toshiba

2. Cryostat

3. Photos

Ribs inside cryostat

Pipes



Main body (Φ2.4m, H3.8m)

Welding on the connection port

Connection port to cryo-cooler unit

Photos by T.Suzuki at Toshiba Keihin Factory

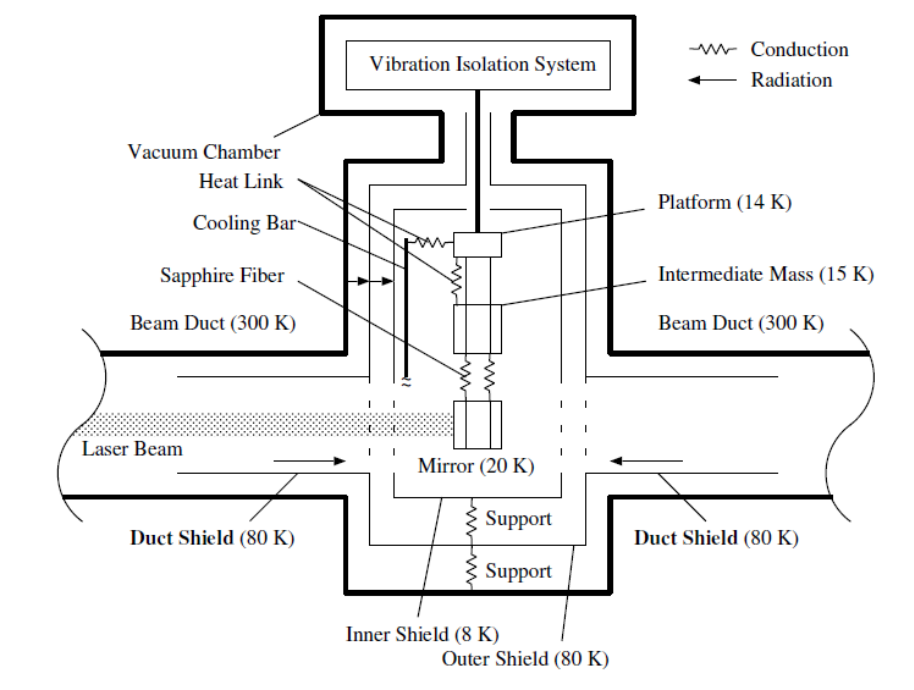
4. Cryogenic duct

1. Outline

Cryogenic ducts are along optical axis
and next to cryostat.

17 m in length, 0.9 m in diameter,

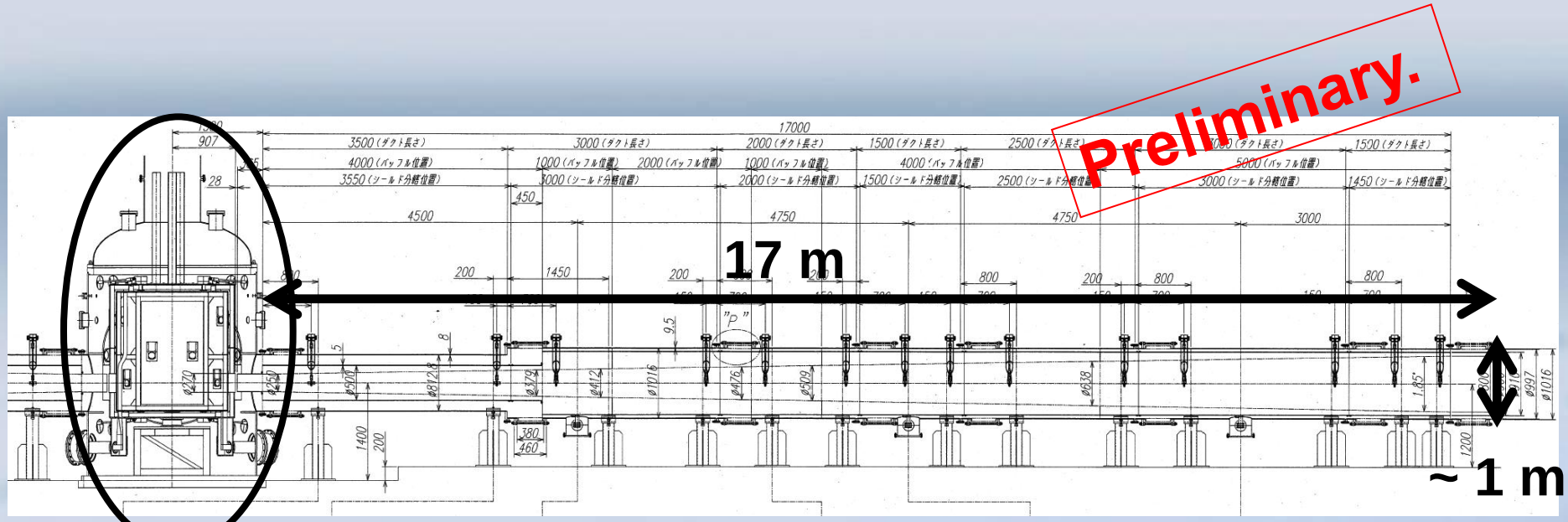
Baffles to prevent propagation of 300 K radiation



4. Cryogenic duct

2. Design : in progress

Details : K. Yamamoto talk tomorrow afternoon



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

3. Cryocooler

5. Vibration test