KAGRAの低温懸架系

山元　一広

2015 December 18

平成27年度東京大学宇宙線研究所共同利用研究成果発表会

@東京大学柏キャンパス, 柏市、千葉

0. Abstract

Here, I explain

1. **Cryostat installation at KAGRA site**
2. **Cryogenic payload**
3. **Sapphire suspension**

Contents

1. Introduction

Schematic view of KAGRA interferometer

Four mirrors of arm cavity will be cooled.

First km scale cryogenic interferometer

Vibration isolation system (Type A), Cryocooler unit, Cryostat, Cryogenic payload

1. Introduction

Thermal noise : Fundamental noise

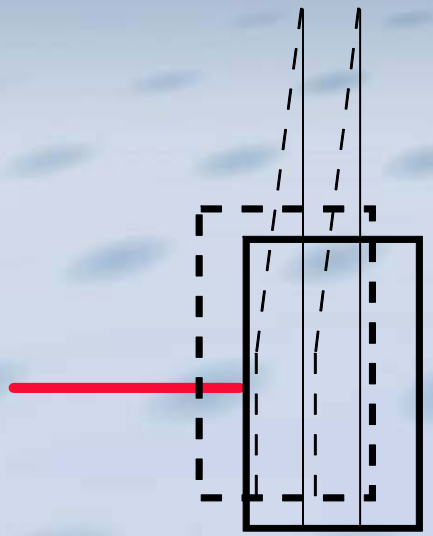
Suspension thermal noise :

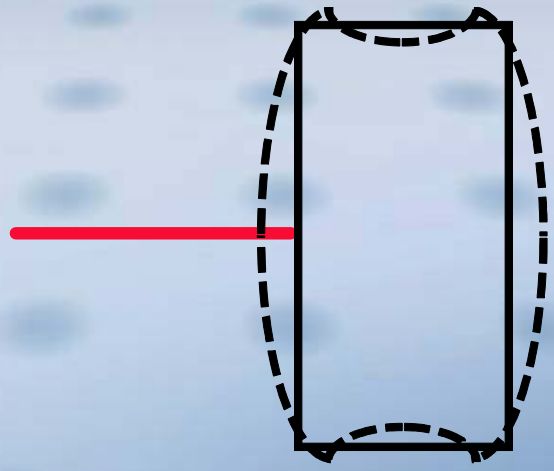
mirror position fluctuation

(vibration of suspension for mirror)

Mirror thermal noise : mirror surface fluctuation

(elastic vibration of mirror itself)





1. Introduction

Fluctuation-Dissipation Theorem

Relation between thermal noise

and mechanical loss in suspension and mirror

Amplitude of thermal noise is proportional to

$$(T/Q)^{1/2}.$$

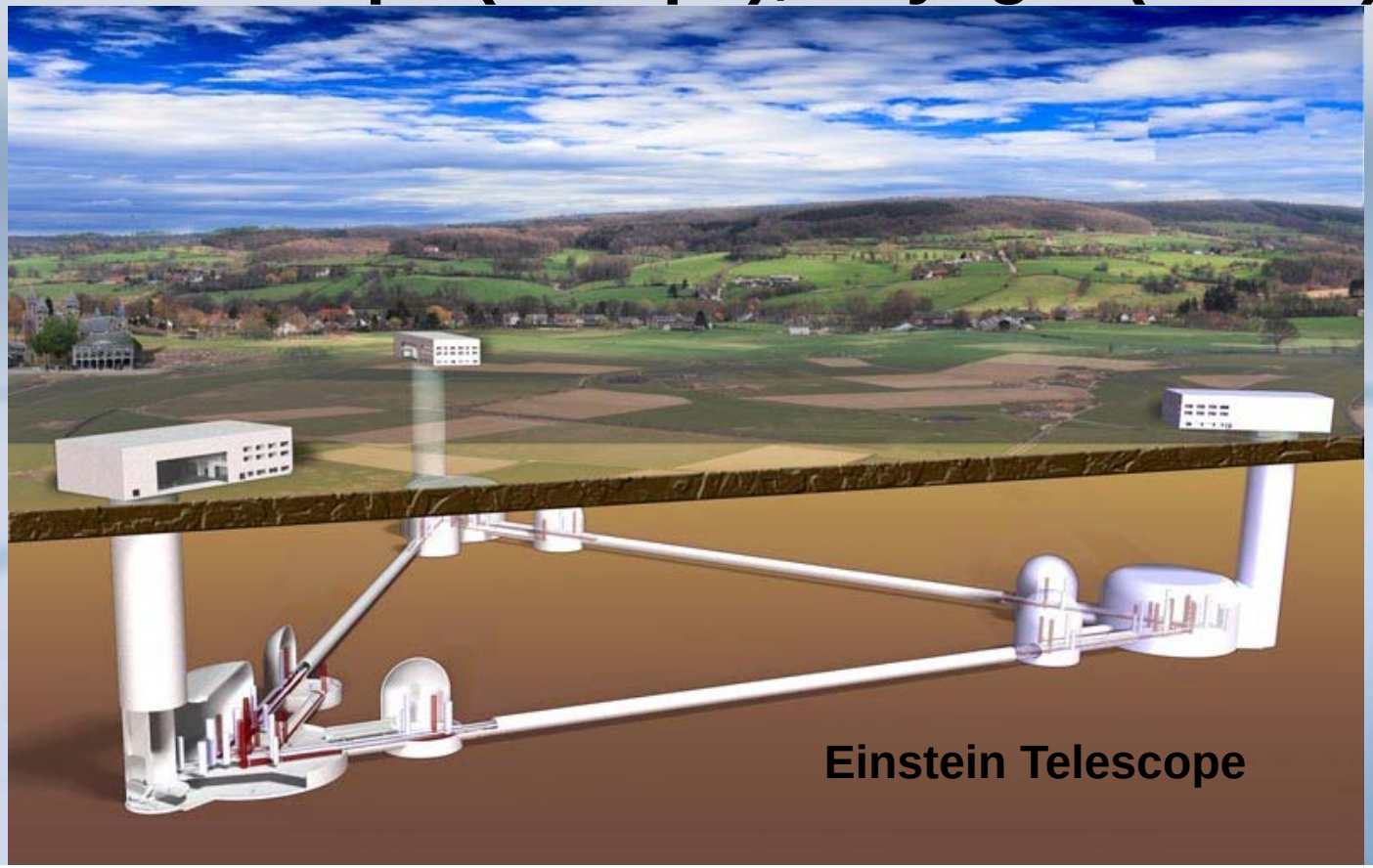
In general, *Q* (inverse number of magnitude of dissipation) depends on *T* (temperature).
KAGRA sapphire mirror is at 20K.

1. Introduction

3rd generation : 10 times better sensitivity

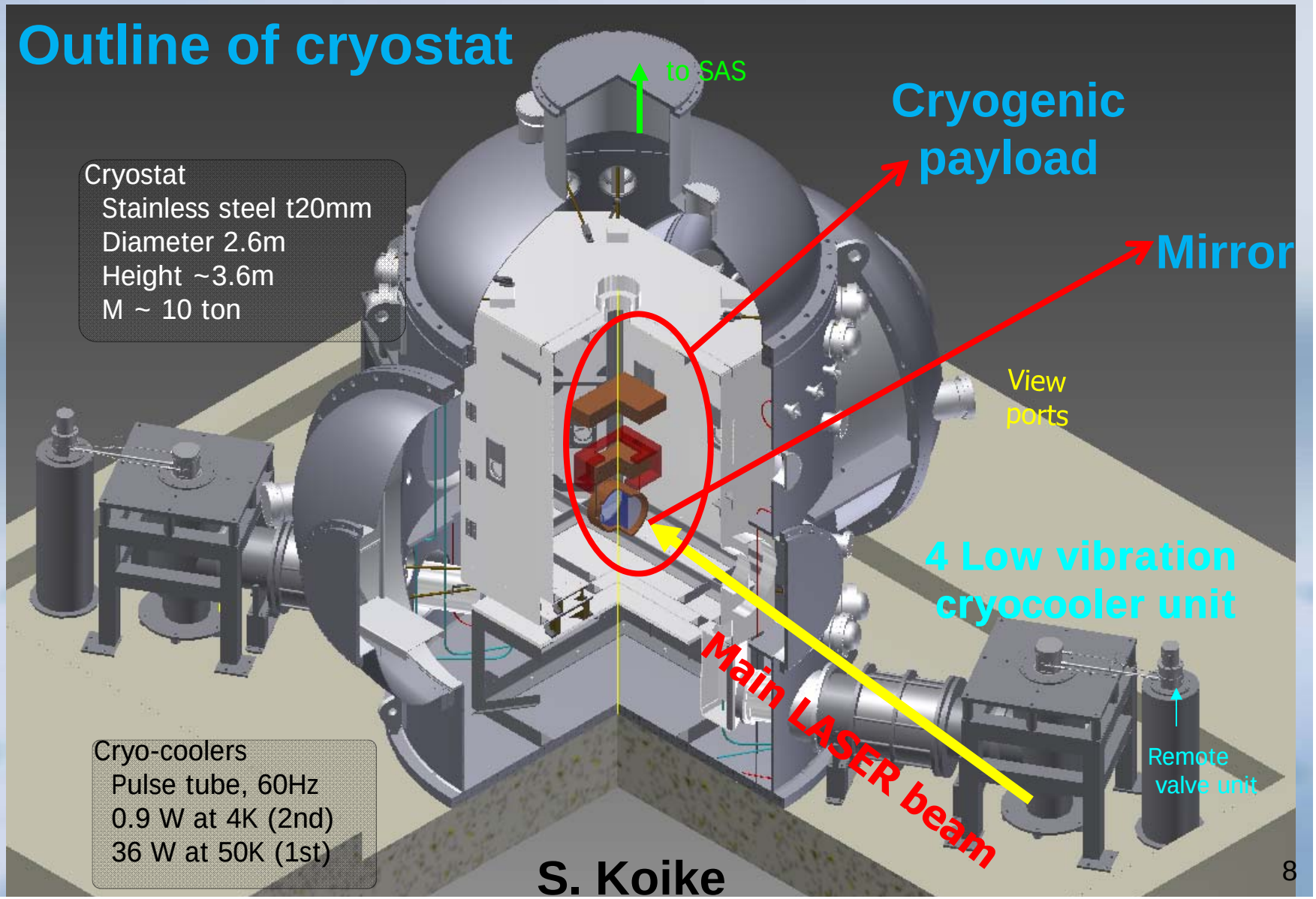
Cryogenic techniques will be adopted.

Einstein Telescope (Europe), Voyager (U.S.A.)



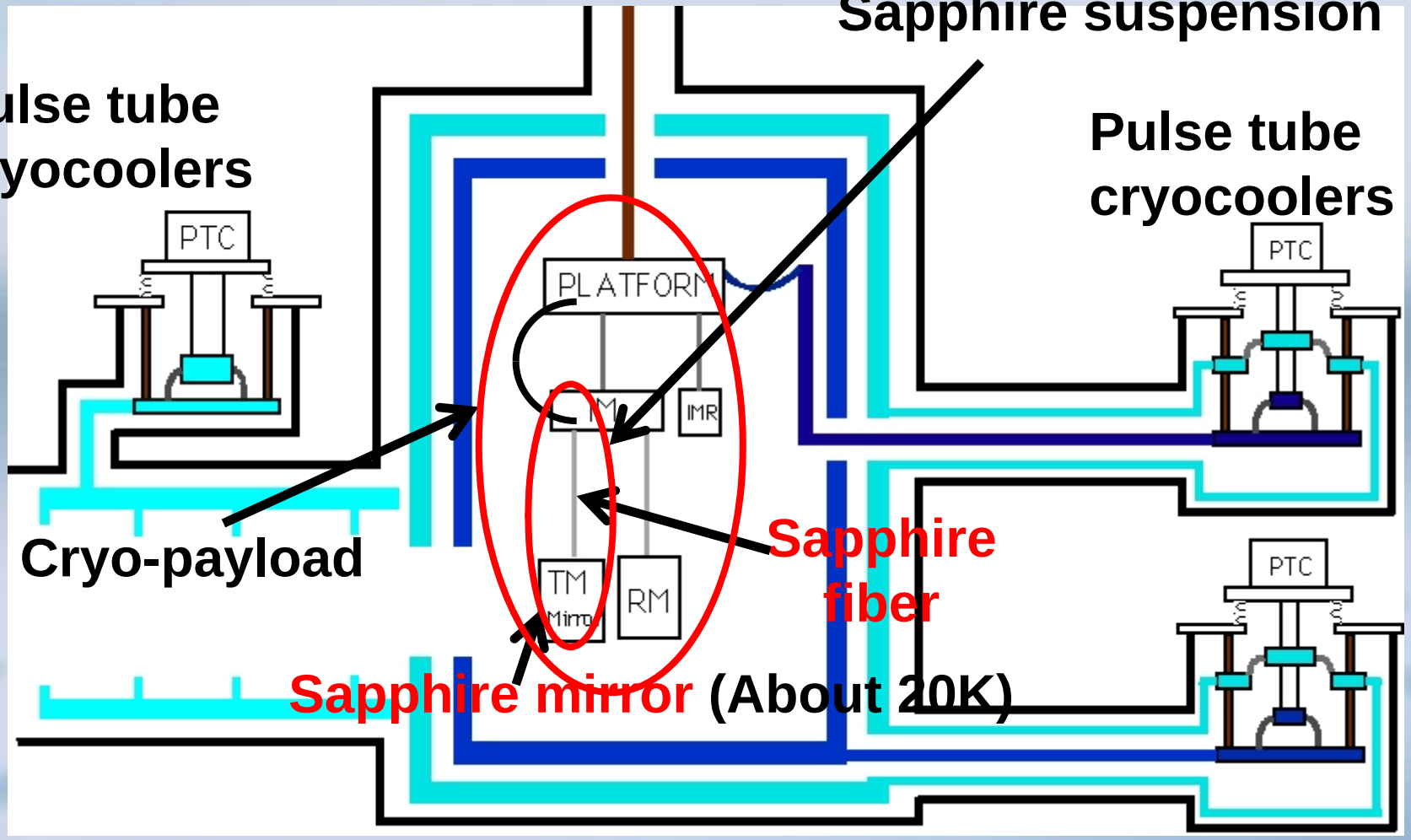
Einstein Telescope

1. Introduction



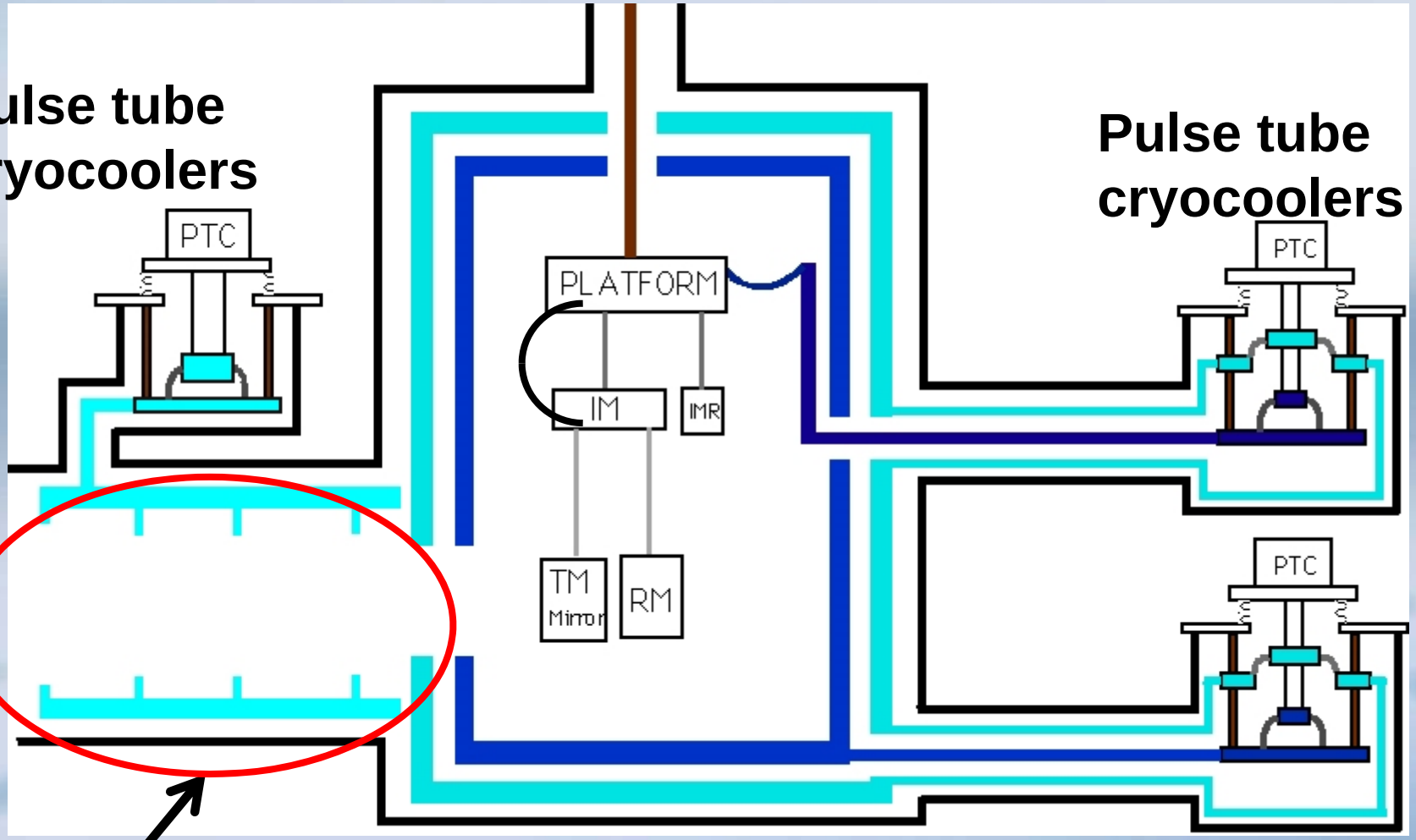
1. Introduction

Schematic view of cryostat and cryo-payload



1. Introduction

Schematic view of cryostat and cryo-payload



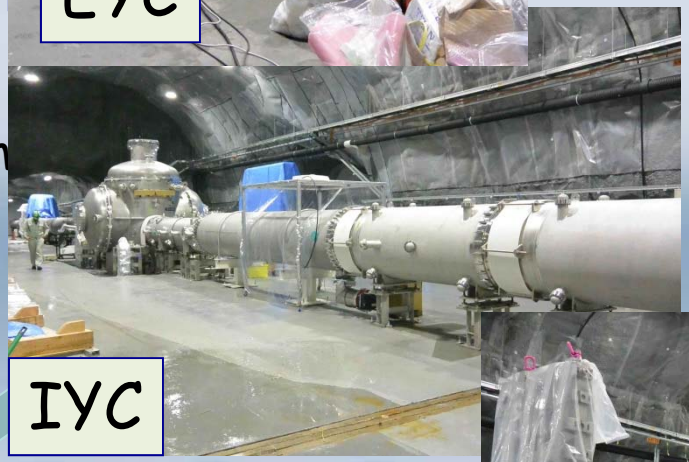
2. Cryostat installation

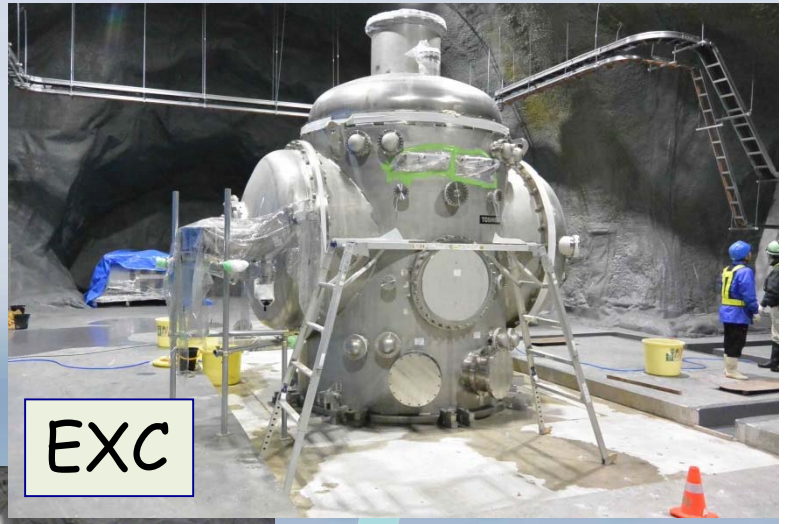
Installation of cryostat is a hard mission !

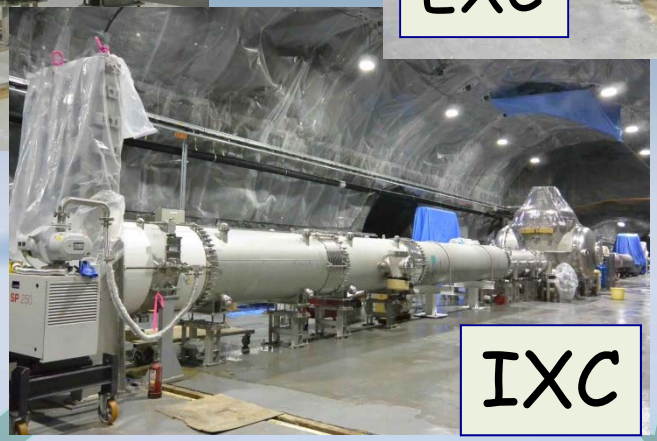
Cryostats are carried along 3 km tunnel !

Assembled Cryostat Photos

All four cryostats were installed.







N. Kimura

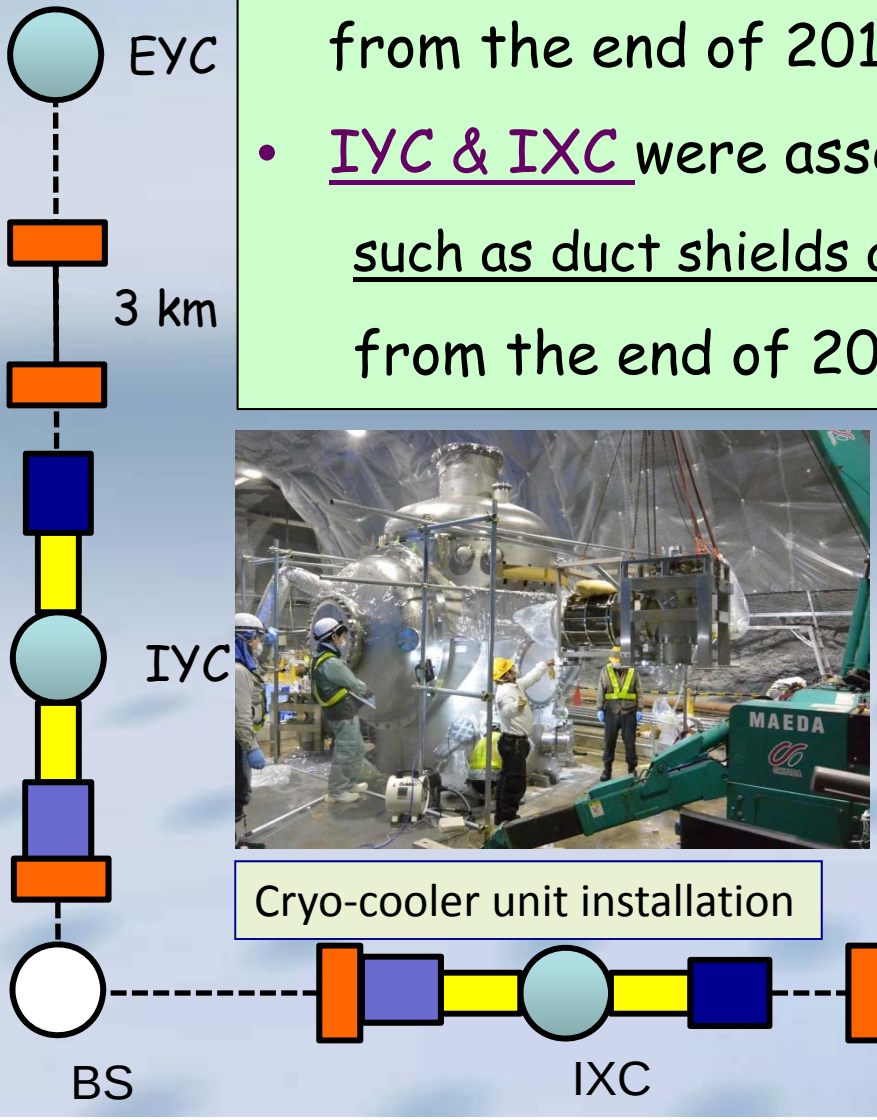
2. Cryostat installation

Cryo ducts are connected to two cryostats in the center room.

N. Kimura

Progress of the cryostat assemble;

- EXC & EYC were assembled as vacuum vessels without duct shields and cryo-coolers from the end of 2014.11 to the end of 2015.1.
- IYC & IXC were assembled with all of components such as duct shields and cryo-cooler units from the end of 2015.2 to the mid of 2015.4.



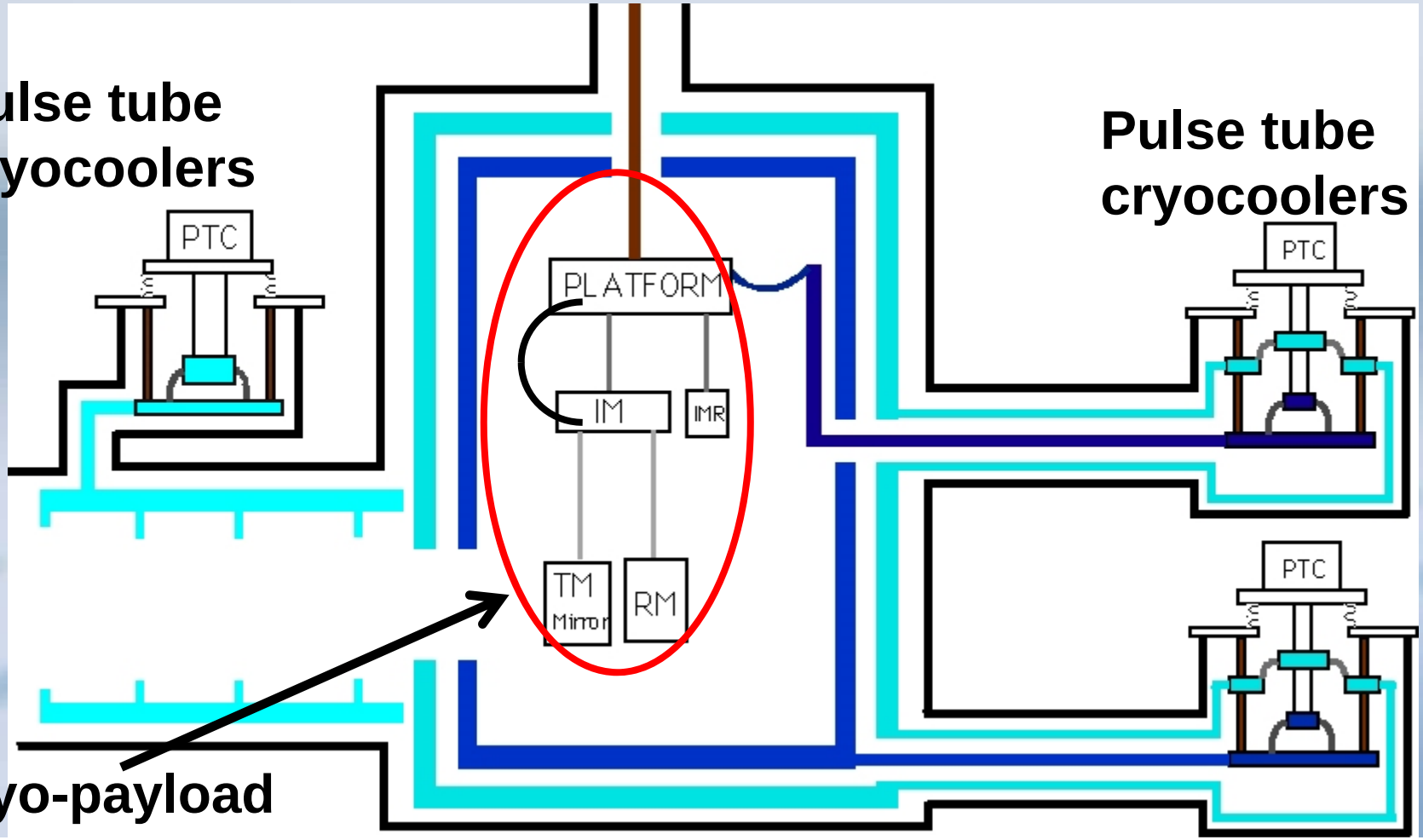
Cryo-cooler unit installation

- Duct Shield
- 12 mL vacuum duct
- 6 mL +6 mL vacuum duct
- Cryostat
- Gate Valve

3. Cryogenic payload

Outline of vibration isolation and cryostat

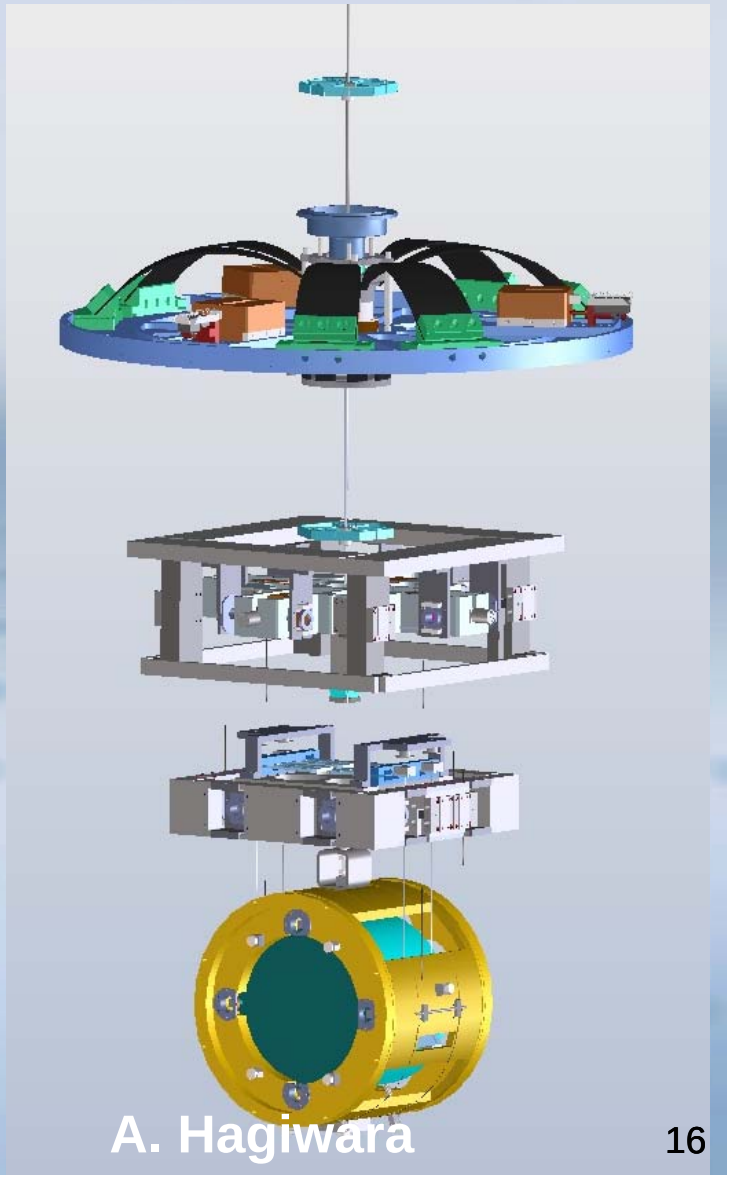
Vibration isolation, adjustment, control, damping, …



3. Cryogenic payload

Design

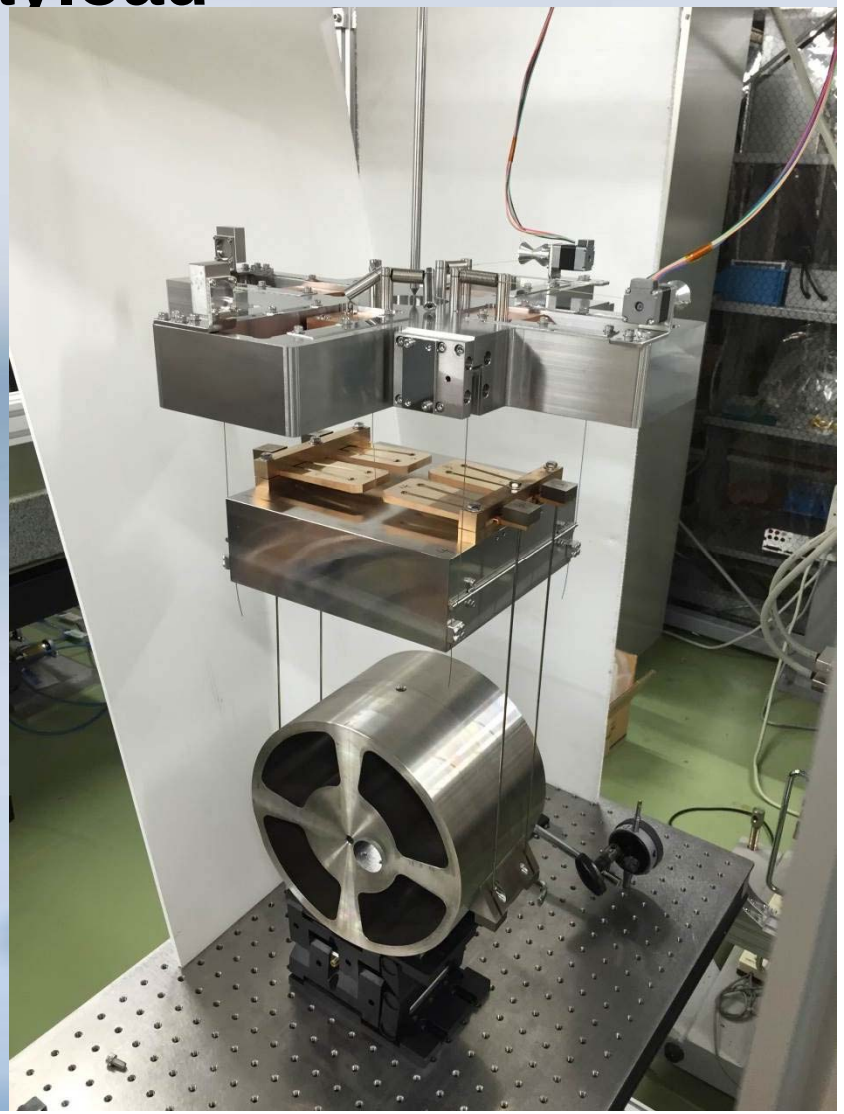
Almost all parts were designed.



3. Cryogenic payload

Prototype test of cryogenic payload

Cooling test on December



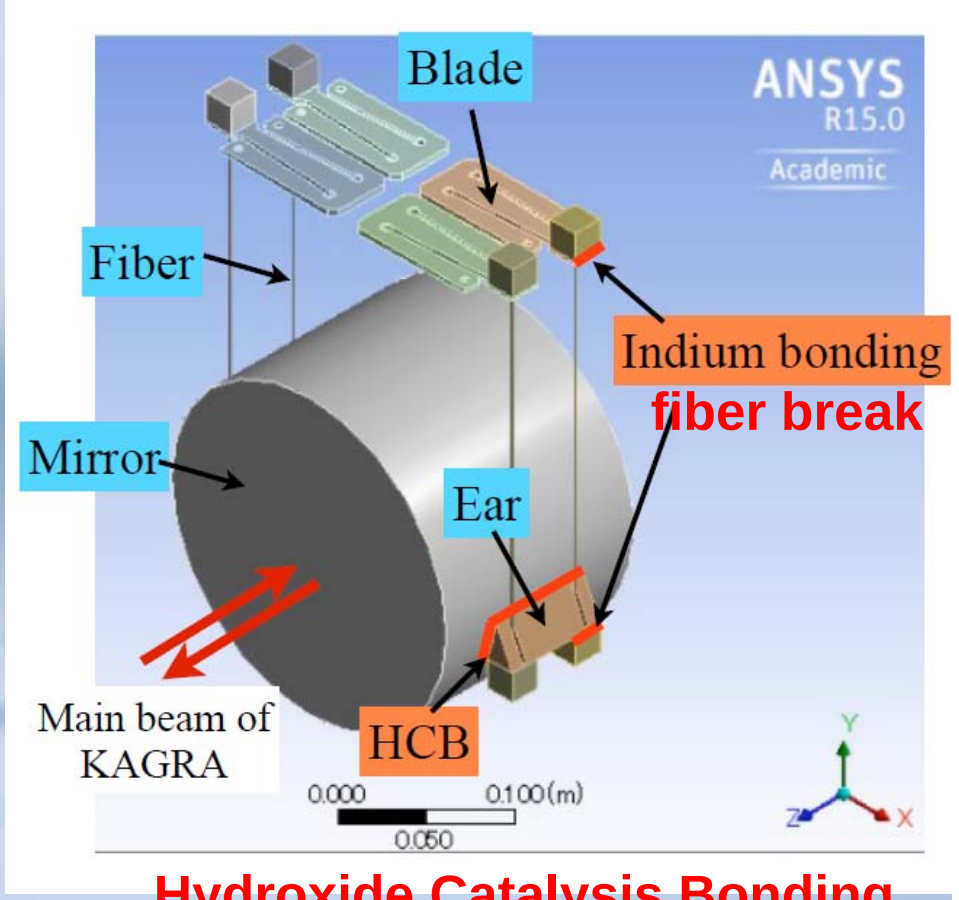
4. Sapphire suspension

Sapphire lop-eared suspension

“Sapphire monolithic lop-eared suspension”

One of the most important parts of KAGRA : Main sapphire mirrors are included.

All parts are made from sapphire.



Hydroxide Catalysis Bonding

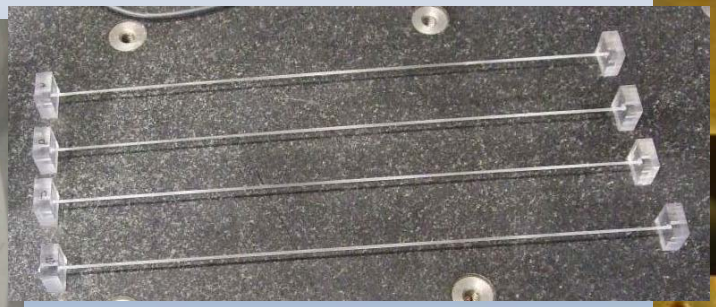
Full size suspension as prototype

4. Sapphire suspension

Full size suspension as prototype

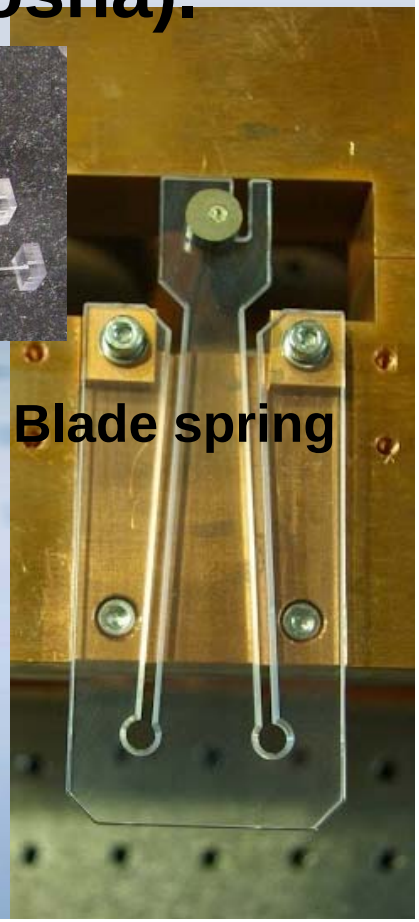
All sapphire parts for full size prototype have already been delivered (IMPEX and Shinkosha).

Sapphire cylinder with flat cuts as dummy mirror



Fibers with nail head

Ears



Blade spring

4. Sapphire suspension

Full size suspension as prototype

Jigs to assemble full size prototype is being prepared.

Some parts were delivered.

4. Sapphire suspension

Full size suspension as prototype

Measurement of shape of sapphire bulk and ears
For precise position of ears, the geometrical shape and ears were measured (by K. Enami, Mechanical Engineering Center, KEK).

5. Summary

Cryostat installation

All four cryostats were installed !

Connection to cryo duct are in progress.

Cryogenic payload

Almost all parts were designed.

Cooling test of prototype will be started soon !

Sapphire lop-eared suspension

All sapphire parts for full size prototype are delivered.

Assembly jig for full size prototype are being prepared.

KAGRA Cryogenics Group

2015.Oct.16

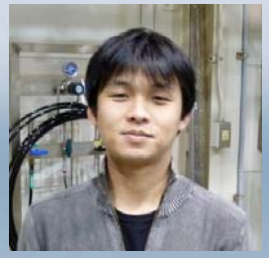
Takayuki TOMARU
Chief
KEK, Assoc. Prof.

Toshikazu SUZUKI
EO and SEO member
KEK, Senior Fellow

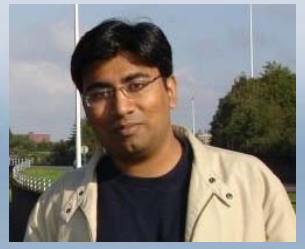
Nobuhiro KIMURA
Cryostat sub-chief
KEK, Assoc. Prof.

Tatsuya KUME
Surveying, Alignment
KEK, Assoc. Prof.

Kazuhiro YAMAMOTO
Cryo-Payload sub-chief
ICRR, Assist. Prof.



Suguru TAKADA
Cryogenics
NIFS, Assist. Prof.



Rahul KUMAR
Simulation, Payload
KEK, PD

Kieran CRAIG
Payload
ICRR, PD

Hiroki TANAKA
Cryo-Payload, Q
ICRR, Grad. Student

Takahiro MIYAMOTO
Cryo-Payload
ICRR, Grad. Student

Shinichi TERASHIMA
Machining
KEK, Technical Staff

Iwao MURAKAMI
Welding, Assembly
KEK, Technical Staff

Ayako HAGIWARA
CAD
KEK, Technical Staff

By T. Tomaru
(Revised by K. Yamamoto)

Acknowledgement

Supported by

Mechanical Engineering Center, KEK

Machine shop, The Institute for Solid State Physics, The University of Tokyo

Thank you for your attention !

Acknowledgement

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. 2017)

European people can visit Japan for KAGRA.

Acknowledgement

ELiTES meeting

1st : 3 Oct 2012

2nd : 4 Dec 2013

Acknowledgement

ELiTES meeting

3rd : 9 Feb 2015

4th : 2 Dec 2015