Cryogenics sub-Group (CRY) Report

21. Jun. 2016

Cryogenics Subgroup Chief, KEK

Takayuki TOMARU

Missions of Cryogenics Subgroup

1) Realization of Cryogenics Mirror Suspension System in KAGRA
2) Mirror Cooling System (Cryostats and Cryocoolers)

Major Milestones of CRY toward bKAGRA-1

- 2016. 5 - 7 X-end and Y-end cryostats assembly
- 2016. 8 - 10 Cooldown test of X-end and Y-end cryostats
- 2016. 12 End of fabrication of 4-cryogenic pendulums
- 2017. 2 - 3 Assembly of sapphire parts onto two End Mirrors (ETMs)
- 2017. 4 - 8 Cryogenic test of ETMs
- 2017. 8 Assembly of sapphire parts onto two Input Mirrors (ITMs)
- 2017. 9 - 10 ETMs installation into cryogenic payload (pendulum)
- 2017. 10 – 11 Cryo-Payload installation into X-end
- 2017. 12 –
  2018. 1 Cryo-Payload installation into Y-end
- 2018. 1. Short test of Michelson by Cryo-Payload at room temperature
- 2018. 2 - 3 Cooldown of X-end and Y-end Cryo-Payloads.
- 2018. 3 bKAGRA-1 run

- We can not make perfect payloads …
- Mechanical Q of sapphire suspensions can not be sufficiently high …
- Payload control system can be noisy …
- Cryostat can not reach to sufficiently low temperature …
- Vibration level of cryocoolers can be large …
- We can not have sufficient test …

But

We absolutely keep schedule

- 2018. 1 Completion of Two ETM cryo-payloads installation
- 2018. 3 Ready of Cryo-Michelson

2015 PABのコメントに対する回答

Details of
Cryogenic sub-Group Report

KAGRA Cryogenics subGroup

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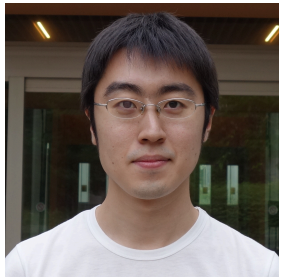

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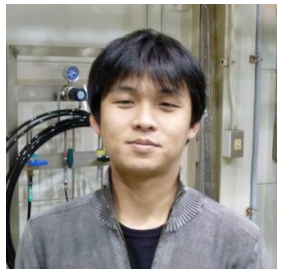
International Collaboration



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Cooling System

2015 External Review

Recommendation: Vibration measurements with the cryo-coolers in operation should be repeated at appropriate locations corresponding to the final design configuration, to more accurately assess vibration transfer. If the resulting spectrum remains as serious as was presented from the preliminary measurements shown, more understanding and development of mitigation techniques will be necessary. This may have radical impact on the cryogenic plant and/or payload designs.

Comment: All the cryo-coolers have been delivered to the KAGRA site, but cryo-coolers have not all been integrated with the end cryostats. Although the cooling time for the radiation shield and vibration levels at the shield have been measured at Toshiba facility, it is highly desirable to demonstrate the cooling and vibration levels inside the real cryostat at the KAGRA site as soon as possible to alleviate remaining uncertainties about the cryogenic operation of KAGRA. If isolation of cryo-coolers vibration should be insufficient, it could render the vibration isolation achieved by super-attenuators useless.

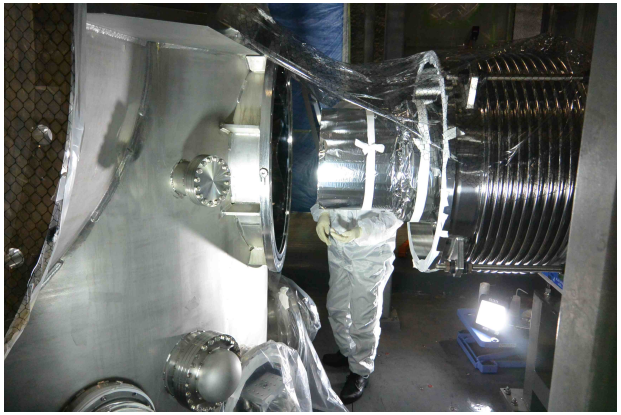
Recommendation: The cryo-coolers should be integrated with at least one end cryostat and vibration isolation system, so that both cooling and vibration isolation can be tested as soon as possible. This will also afford VIS and CRY teams an opportunity to work together on integration of their systems.

Status of the end room cryostats construction

- Assemblage X&Y-end room cryostat from components are progressing,
  and will be completed at the beginning of July 2016.
- Assemblage the end cryostats included connecting 12 cryo-cooler units and4 duct shields.
- Connection of vertical duct between the cryostat and vacuum chamber for VIS will be started after assemblage the end cryostats.
- Vacuum leak test will be done after all of assemblage.

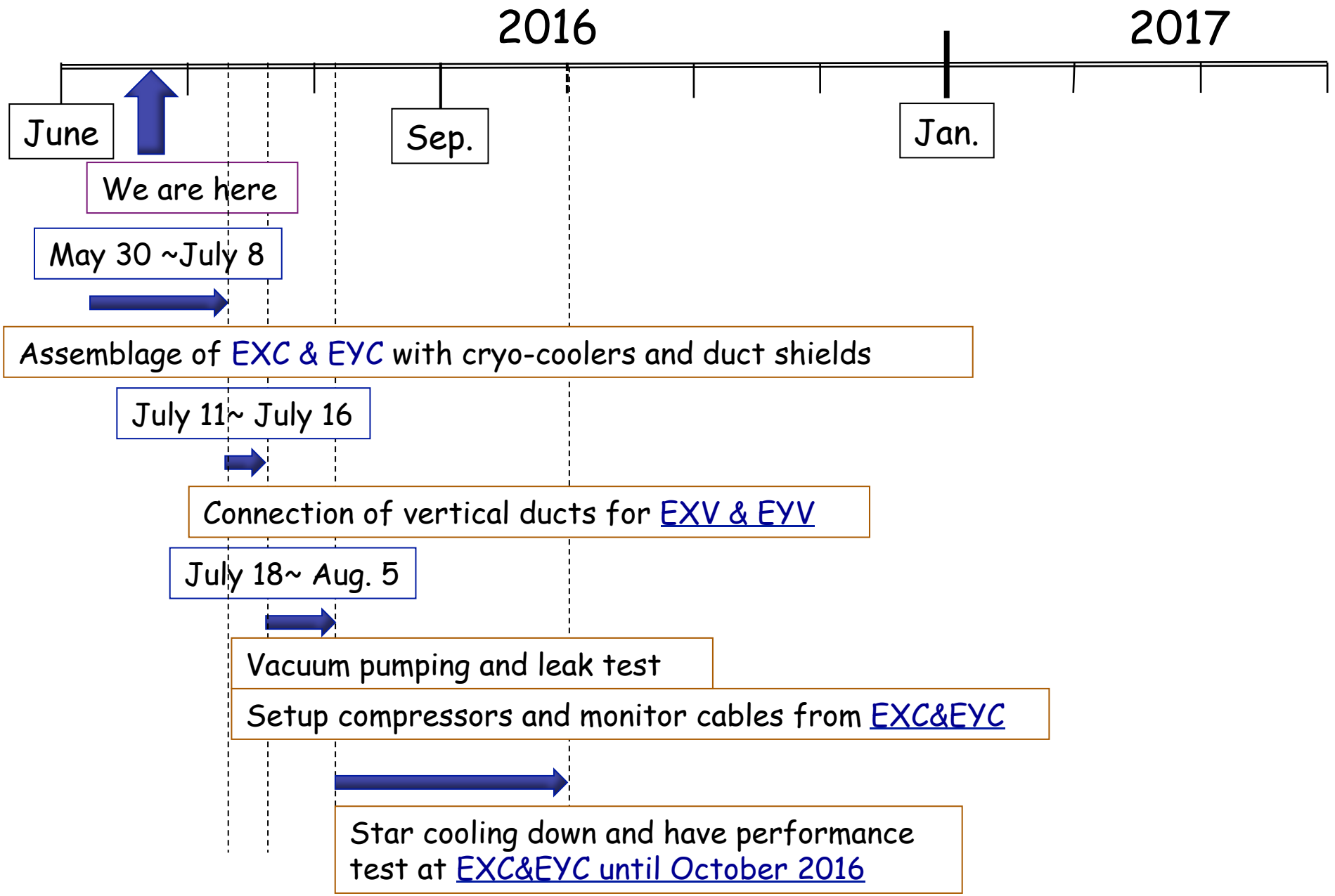
Duct shield transportation

Duct shield installation

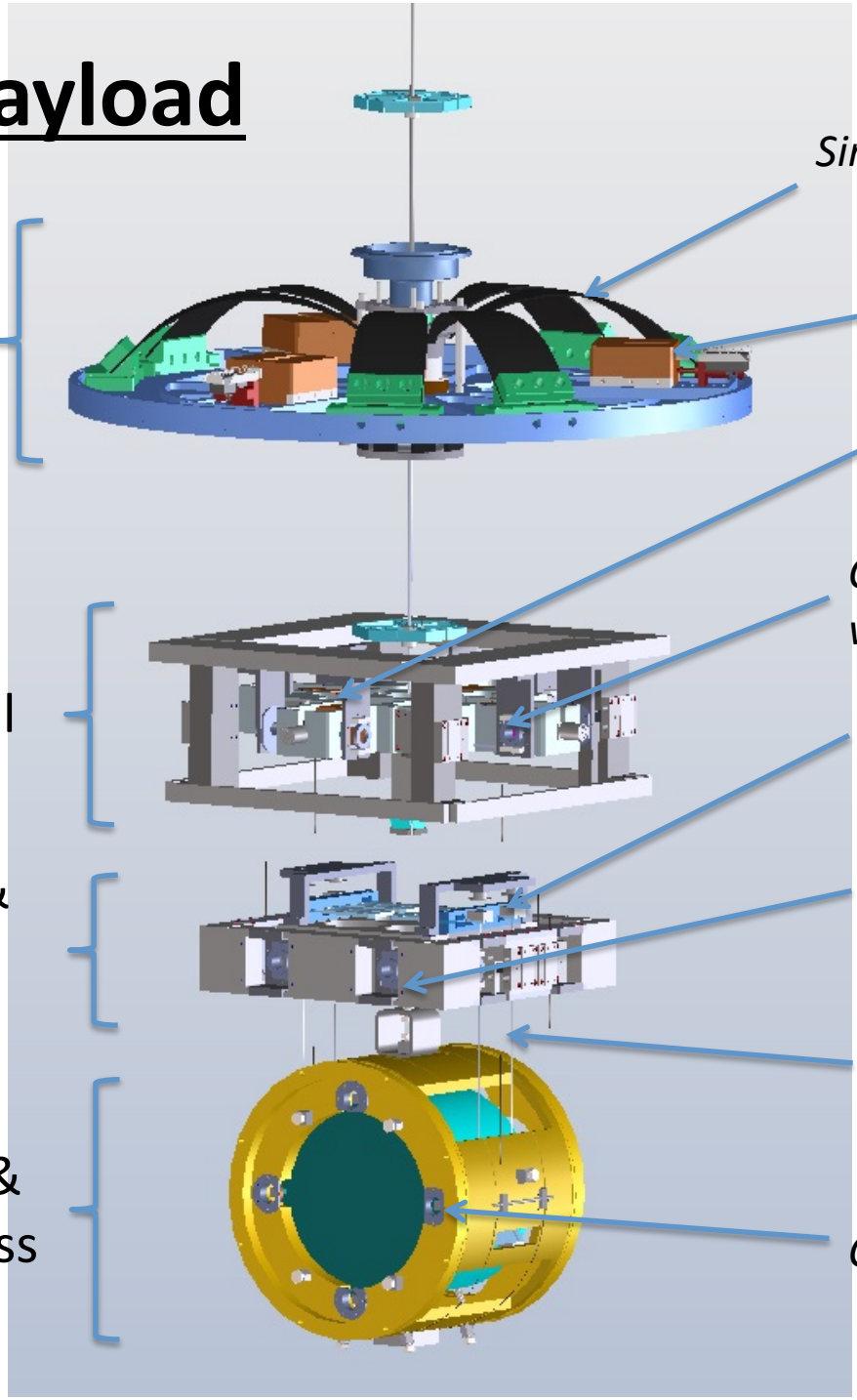


Duct shield connection

Performance Test Plans for KAGRA EXC & EYC



Cryogenic Payload



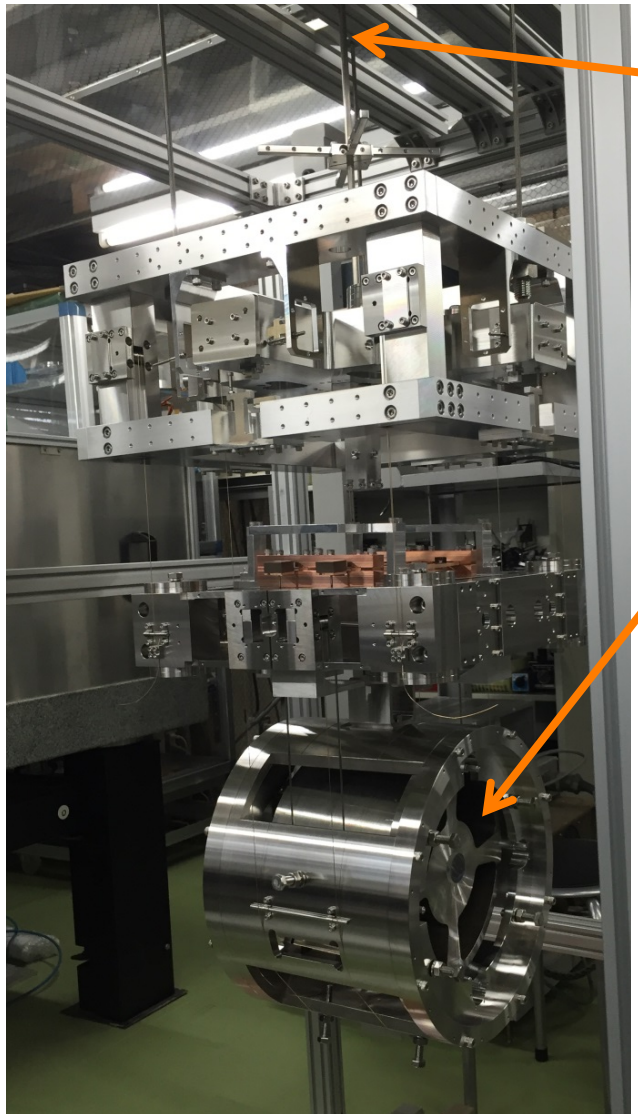
Platform

Marionette & Marionette Recoil Mass

Intermediate Mass & Intermediate Recoil Mass

Sapphire Mirror & Mirror Recoil Mass

Cryogenic Payload No.1 assembly test



Cryogenic payload No.1

Platform is still under designing
Paylaod-1 is suspended by a frame now.

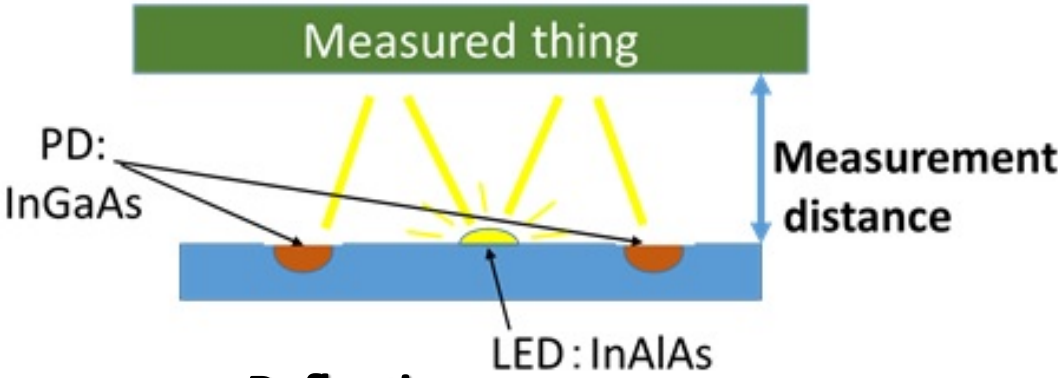
A dummy mirror with same weight
as sapphire is suspended.
Here CuBe blades spring and stainless
steel rods are also used instead of sapphire.

We just checked principle issues of payload and assembly procedure in this
hanging test. And we got some minor advises from VIS folks from their experiences.

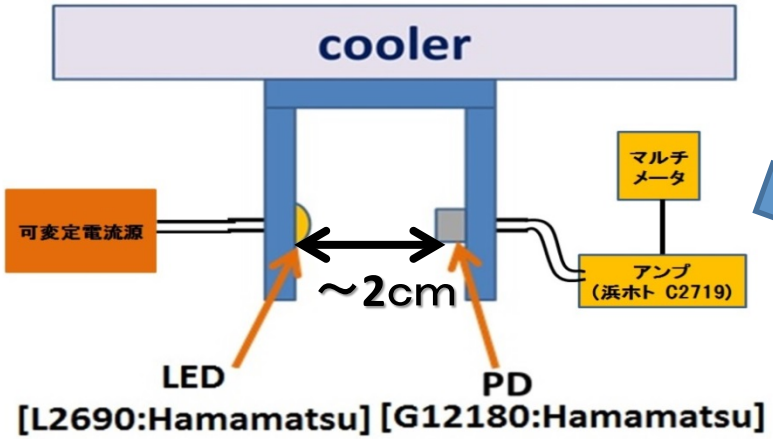
These will be reflected to remaining 3 payload fabrication in this year.

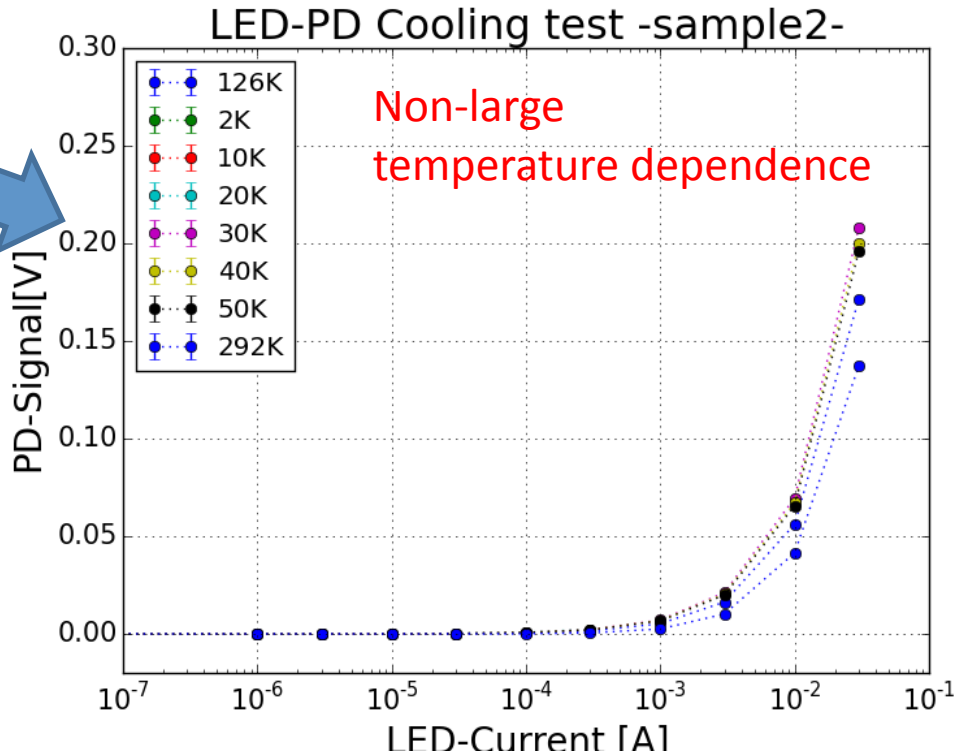
Sensor using cryogenic

We use the reflection type photo-sensors at cryogenic payload, because dynamic range of this sensor is larger than OSEM.



Reflection sensor





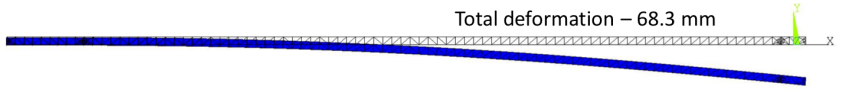
We confirmed to operate a PD and a LED in low temperature. Statistical check of PD-LED performance is under planning.

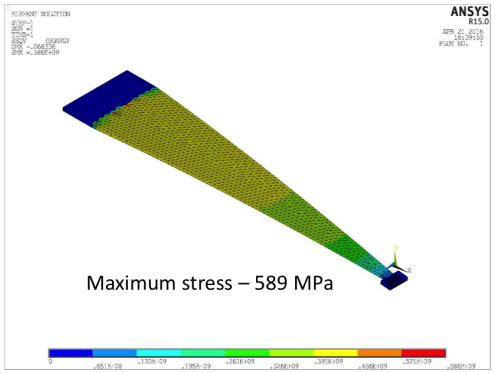
Digital system in KEK

- A digital control system used in NAOJ to test Type-B was moved to KEK to built Cryo-Payload control.

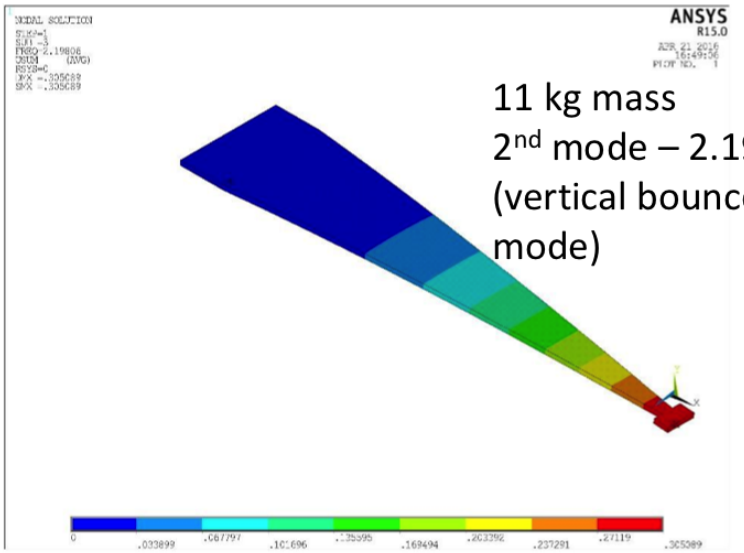
Study of Material Properties at Cryogenic Temperature

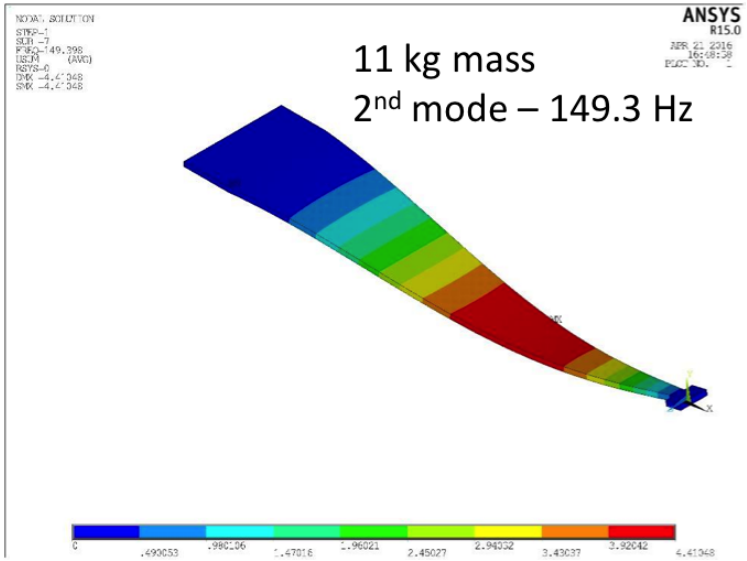
Blade springs for the platform stage



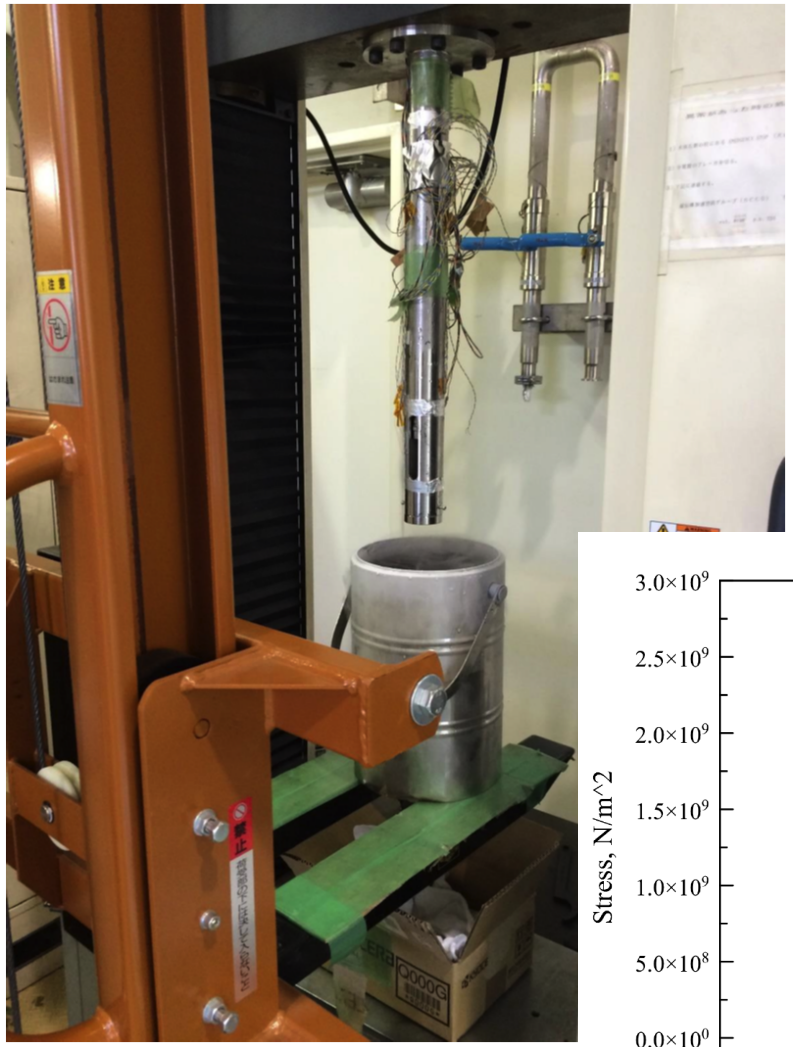


11 kg

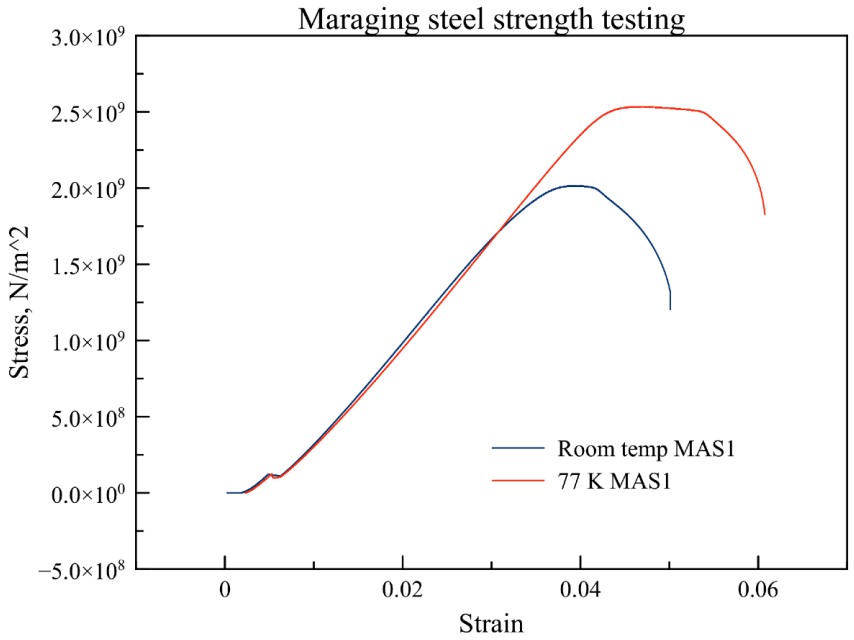




Strength Test



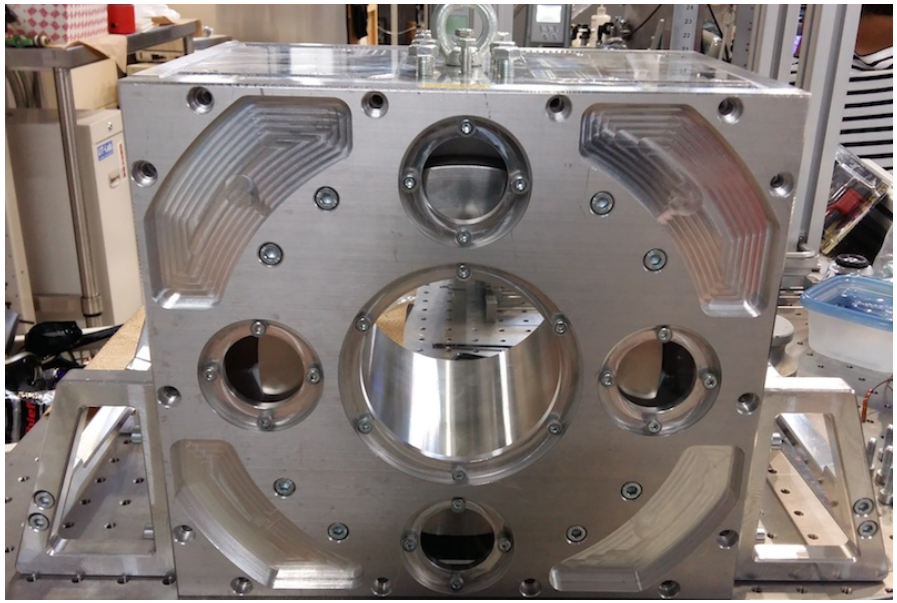
Maraging steel – 1 sample (77 K)
Titanium alloy – 4 samples (77 K)

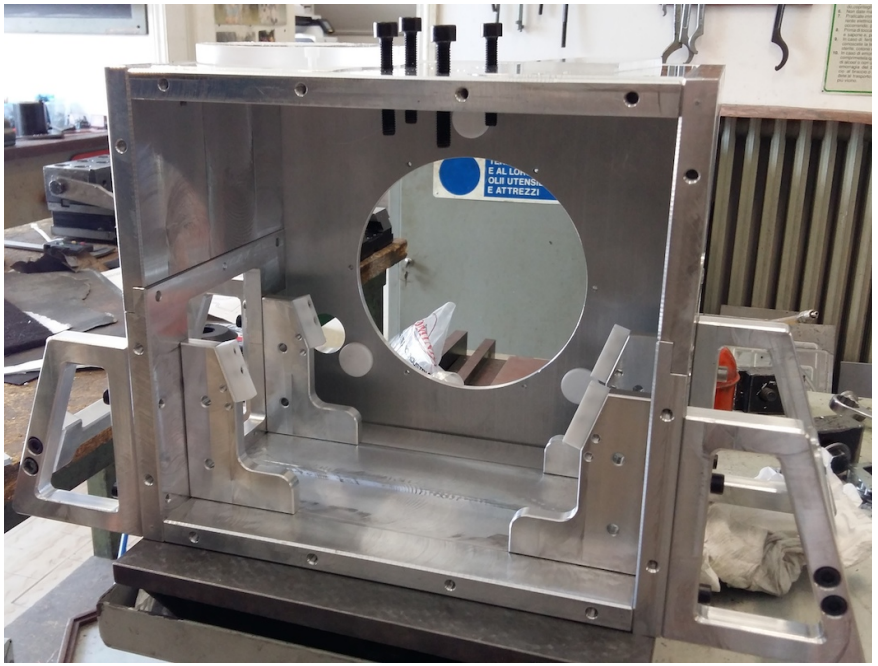


Temp.	Ultimate strength	Breaking stress
300 K	2.0 GPa	1.32 GPa
77 K	2.5 GPa	1.84 GPa

HCB Bonding Jigs

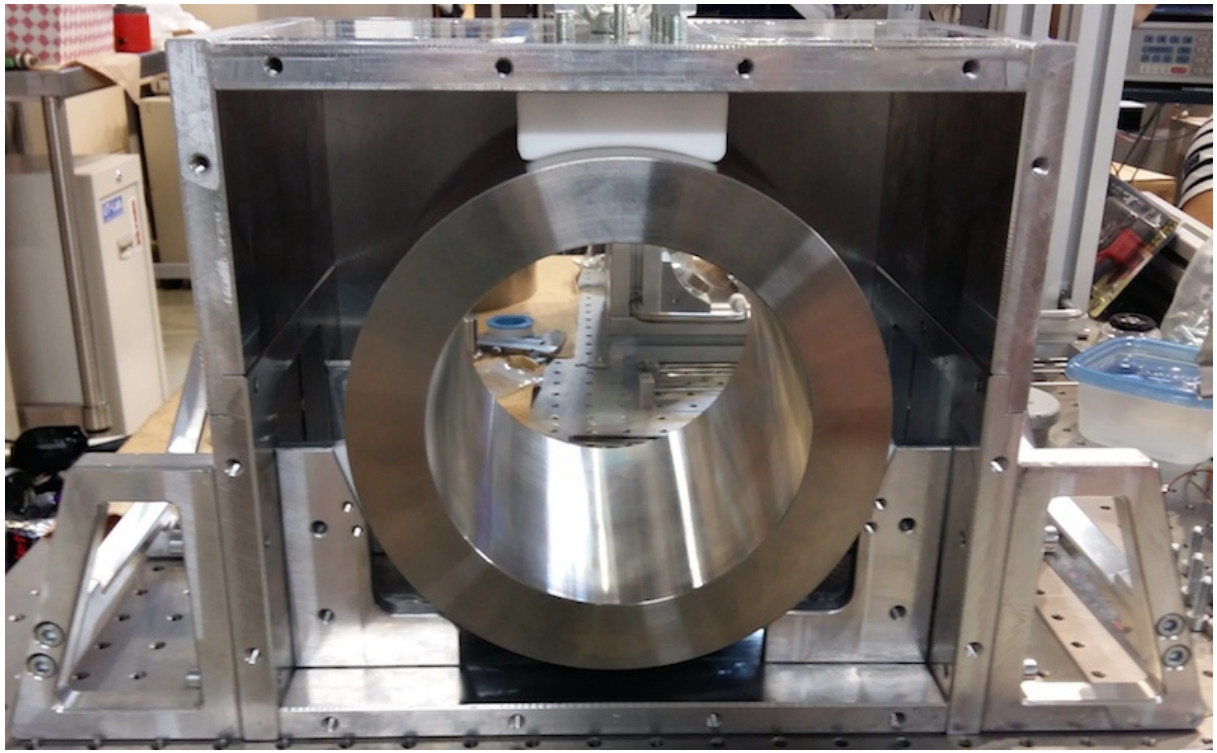
- The jigs for ear positioning during HCB bonding are incorporated into a box, which may also be used for transport and to support the mirror during suspension

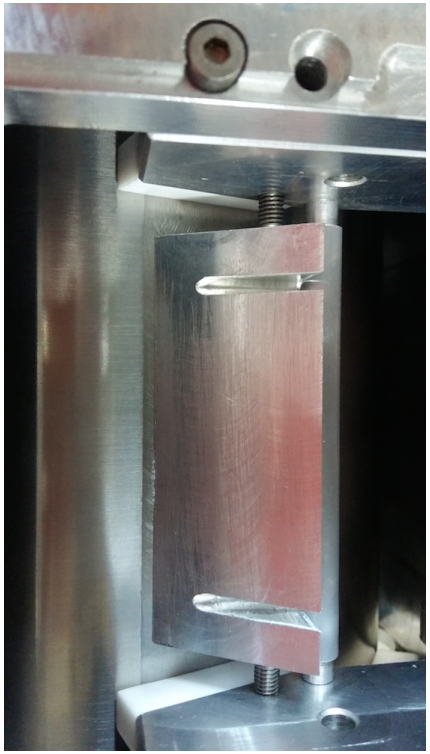




HCB Bonding Jig

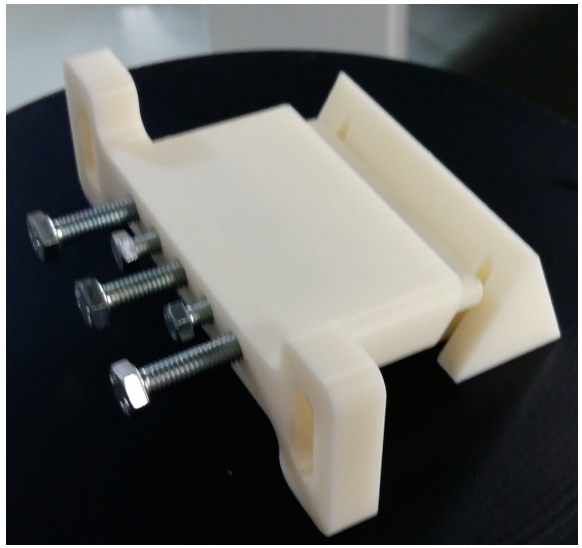
- Mirror is pressed on all sides by teflon
- The box is rotated to rest on the handles during bonding
- Handles parallel to mirror flats
- Ear fixed in all degrees of freedom during bonding





HCB jig testing

- Currently testing with stainless steel mass and ears
- Ear positioning and reproducibility will be verified using 3D measurement system
- After verification, sapphire dummy mass and sapphire ears will be used



KAGRA HCB (rough) Schedule

- Prototype box arrived is in Japan
- Testing with metal parts should be done this month
- Helios will be in Japan during July/August
- If necessary, further discussion using metal parts can be done at the start of this time
- Sapphire parts will be bonded during Helios' visit, and the prototype sapphire suspension will begin construction