

Cryogenics sub-Group (CRY) Report

21. Jun. 2016

Cryogenics Subgroup Chief, KEK

Takayuki TOMARU

Missions of Cryogenics Subgroup

- 1) Realization of Cryogenic 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 Cool-down 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 the X-end cryostat
- 2017. 12 –
2018. 1 Cryo-Payload installation into the Y-end cryostat
- 2018. 1. Short test of Michelson by Cryo-Payloads at room temperature
- 2018. 2 - 3 Cool down of the X-end and Y-end Cryo-Payloads.
- 2018. 3 bKAGRA-1 run

We don't have sufficient time to do full test and improvement of cryo-payloads and cryostats.
These can be imperfect version...

But

We absolutely keep

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

schedule

Answers to PAB 2015 Recommendation

Recommendation 8:

It is critically important to understand the movement/tilting of the floor especially at the upper payload base location, and to find a reliable solution. Systematic continuous monitoring of this is recommended and, in parallel, monitoring of environmental data to find correlations and to find a systematic solution.

Answer:

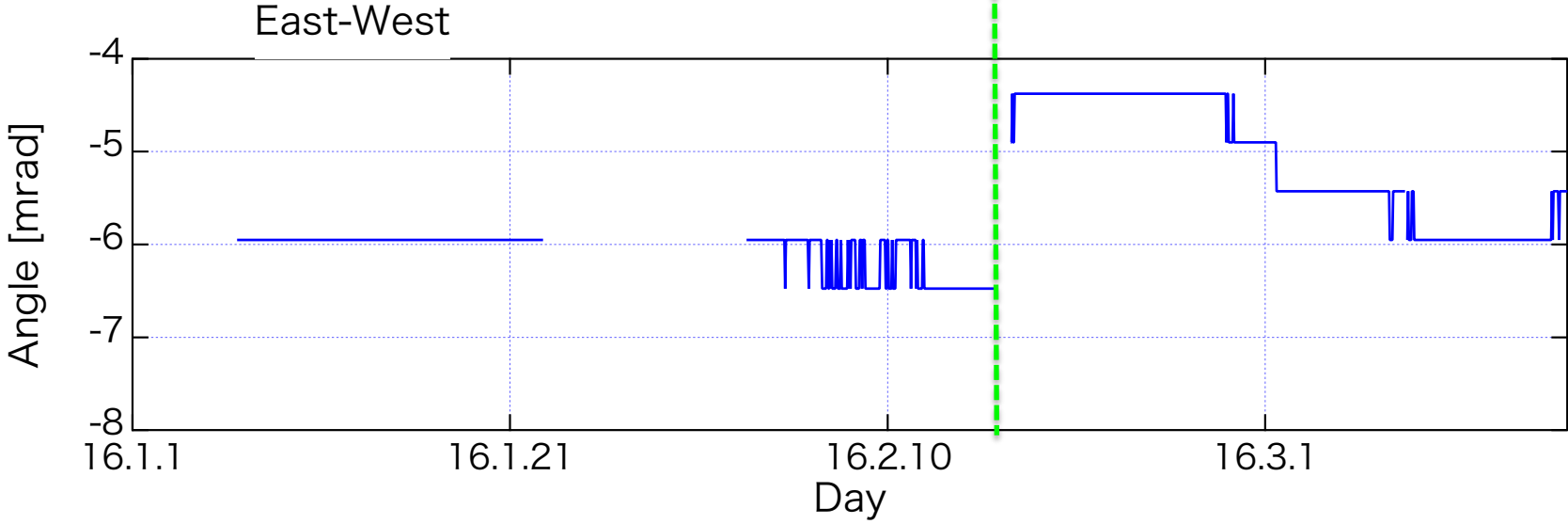
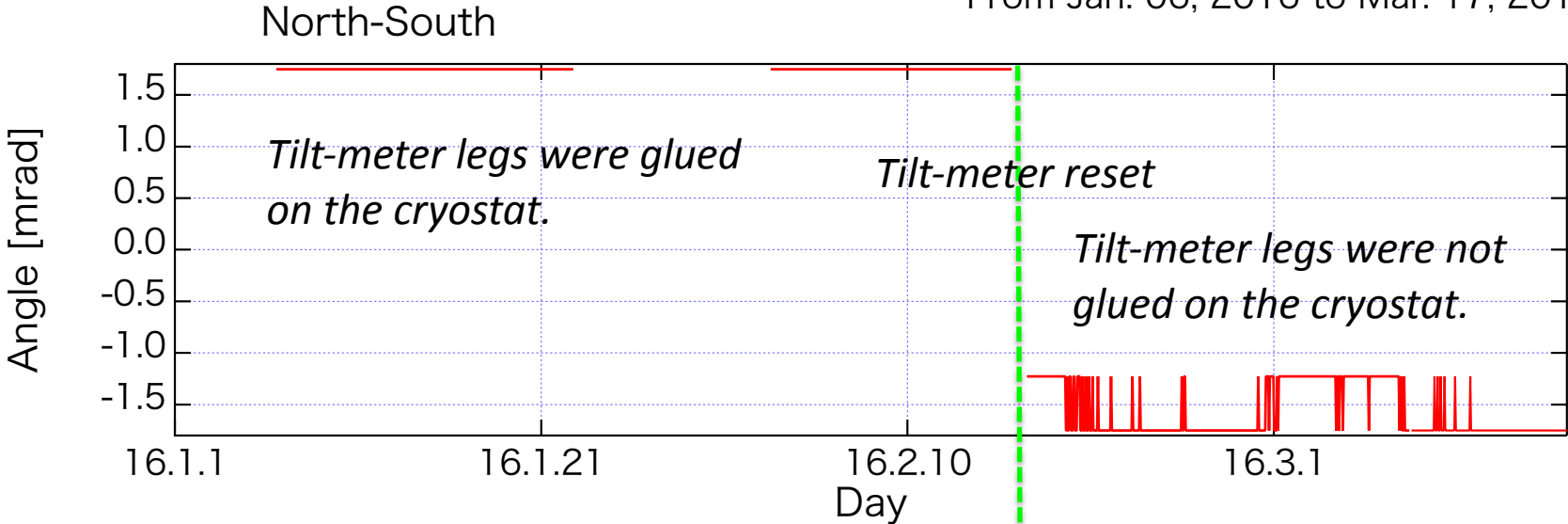
*We put a plumb bob on the Y-end through the vertical hole from the second floor to the roof of the clean booth, and started to monitor a change of installed positions. Also we put a digital inclination sensor on the cryostat at the X-front. Those monitors have worked since September 2015. A sensitivity of monitors are 0.01 deg (nearly equals to 0.2 mrad). Although we had a less groundwater in this early spring, **no significant movement of position was observed until May 2016.***

Positioning error of cryostat and of vertical shaft of type-A vibration isolator seem to be within an adjustable range of their designed structure.

The cross-duct with 900 mm in diameter will connect between the vertical shaft and the top of the cryostat at both X and Y ends in middle of July 2016. At that time, we will measure a relative disagreement of positions and correct them.

Tilt Measurement of Y-front Cryostat

From Jan. 06, 2016 to Mar. 17, 2016



Answer to PAB 2015 Recommendation

Recommendation 9:

The payload integration work in the tunnel should be started in the most efficient and safest environment to minimize risks. Given the confined space/limited egress hazard at the X-end, this suggests starting at other locations.

Answer:

We are under considering to do payload assembly at Toyama Univ. or KAGRA center room to minimize risks at X and Y-ends. And we can choose Y-ends for first installation location of Cryo-payloads, but it depends on Type-A suspension test schedules.

We also have “monthly integration meeting” among subgroups toward bKAGRA.

Recommendation 10:

It is of critical importance that KEK remain continuously involved in the cryogenic work.

Answer:

However there exist inter-institute agreement for research of gravitational waves, KEK has no official department that concerns with technology and physics of gravitational waves. One of the important issue is to put a proclamation of further collaboration into “KEK Roadmap 2018” for continuing a research of GW in KEK and for keeping KEK as a responsible institute of KAGRA project. For helping this matter from outside of KEK, Cosmic-ray Researchers Congress (CRC) sent a letter for KEK to require a long term support of KAGRA. Inside of KEK, we are making effort to increase cross-sectional collaborators for organizing a research group under a consent of the Director General of KEK.

Details of Cryogenics sub-Group Report

KAGRA Cryogenics subGroup



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KEK, Assoc. Prof.



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



ICRR, Assist. Prof.



KEK, Prof.

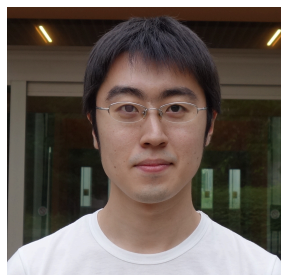


Anshul KUMAR
Simulation, Payload
KEK, PD

CRY team has good international collaboration among Japan, Taiwan and Italy



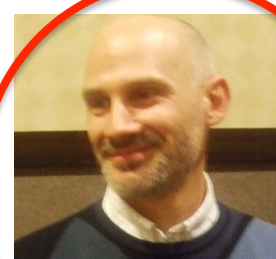
Kieran CRAIG
Cryogenic Payload
ICRR, PD



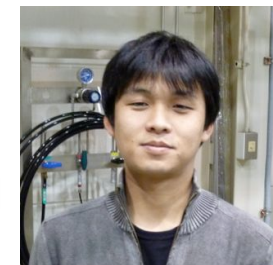
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Cryogenic Payload
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Yuki Inoue
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AS, PD



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Status of the end room cryostats construction

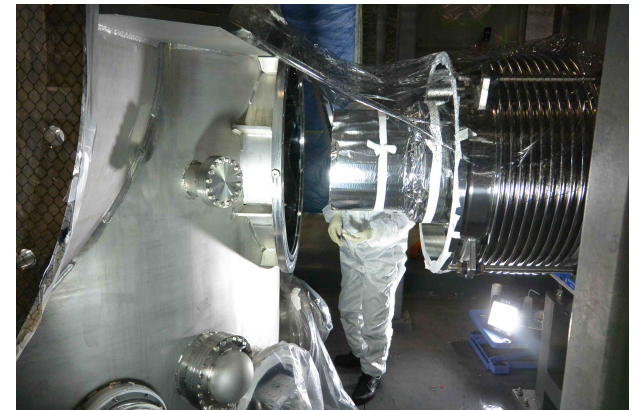
- X&Y-end room cryostat from components including connecting cryo-cooler units and the duct shields are now under assembling, and will be completed at the beginning of this July.
- X-end cryostat have almost completed except connection of vertical duct between the cryostat and vacuum chamber for VIS. This work will be started after assemblage the end cryostats.
- Vacuum test with leak hunting will be started after all of the construction work.
- Performance test of the cryostat shall be finish until end of this Oct.



Duct shield transportation

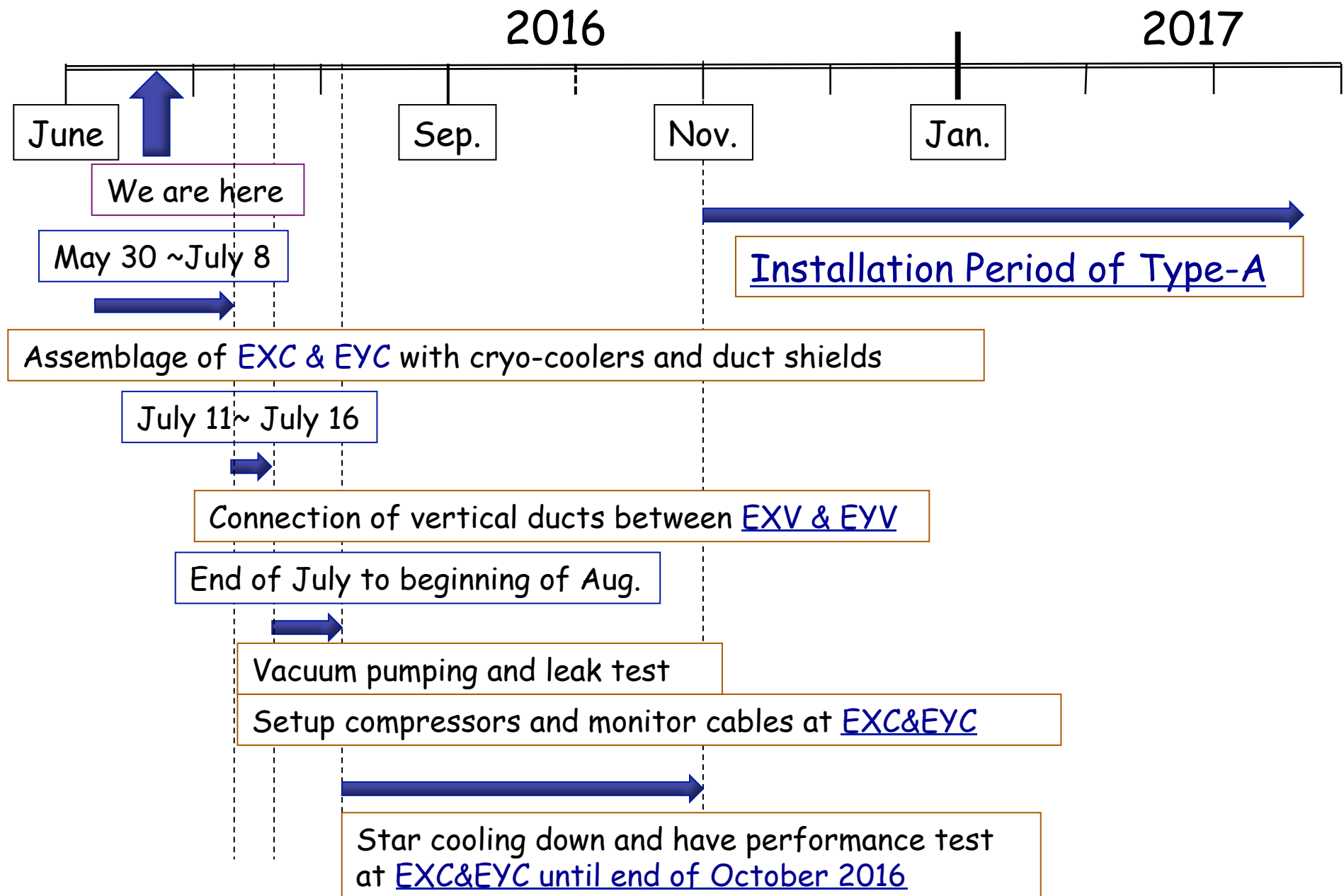


Duct shield installation

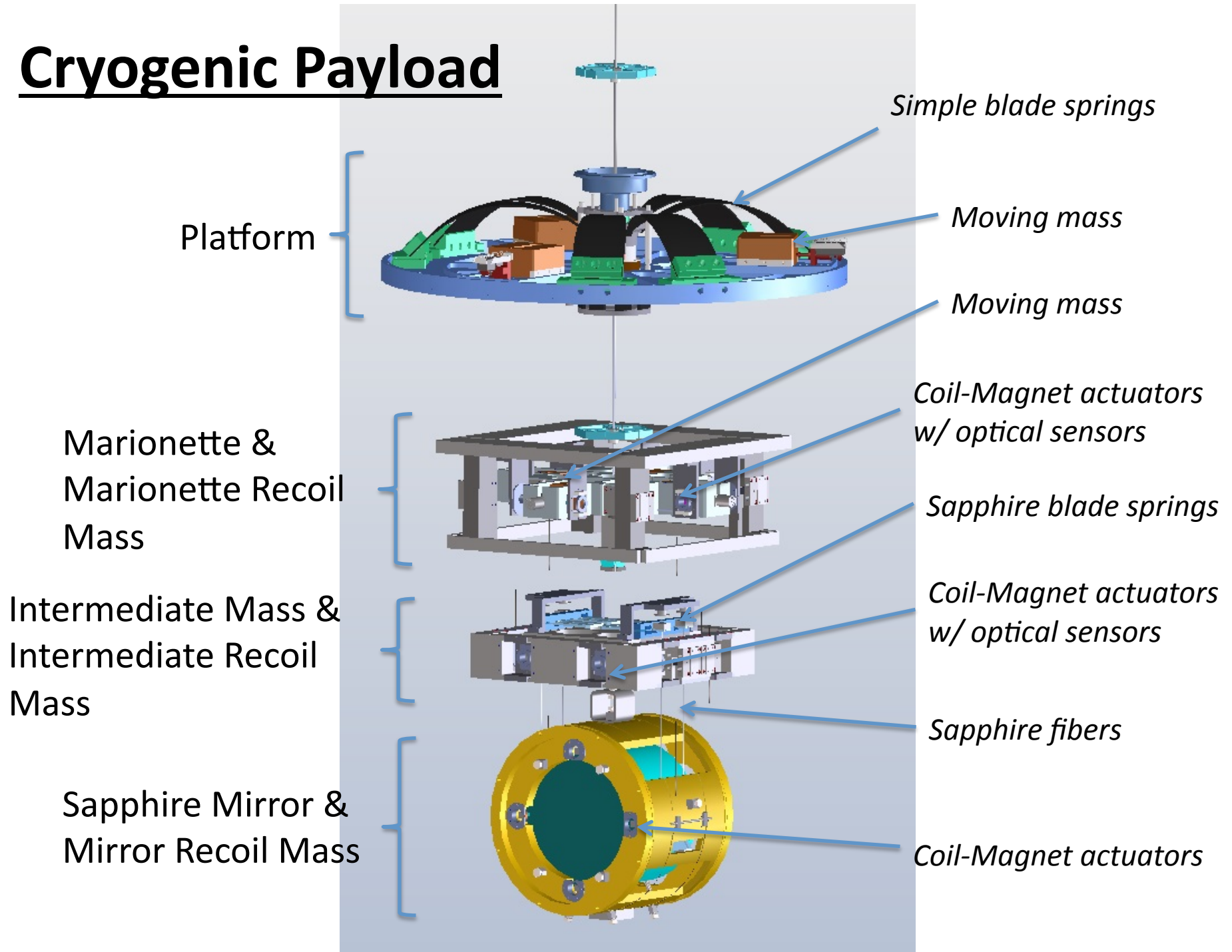


Duct shield connection

Performance Test Plans for KAGRA EXC & EYC



Cryogenic Payload



Cryogenic Payload No.1 assembly test



Fabrication of 1st cryogenic Payload has been done.

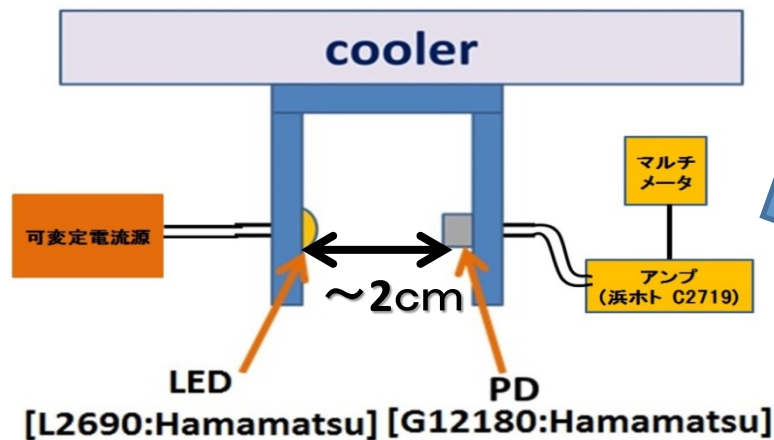
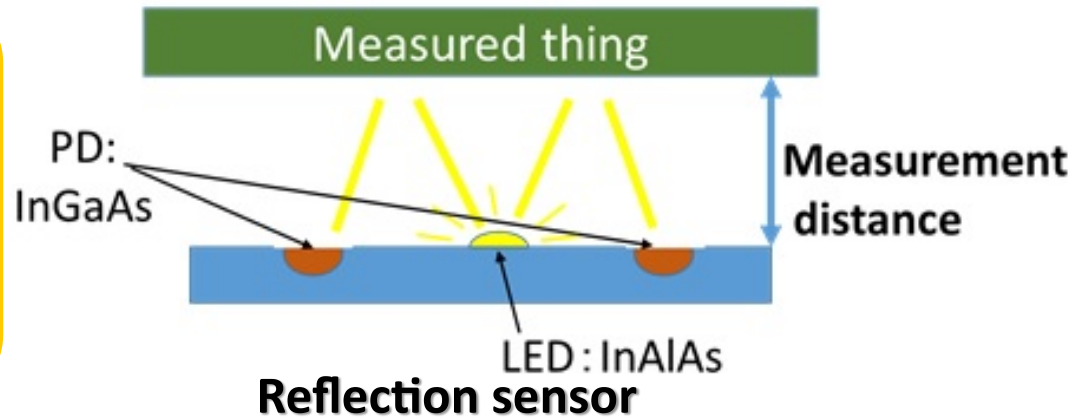
- Platform is still under designing.
Payload-1 is suspended from a frame now.
- Sapphire suspension is still under preparation.
A dummy mirror with same weight as sapphire is suspended.
CuBe blade-springs and stainless steel rods are also used instead of sapphire.

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.

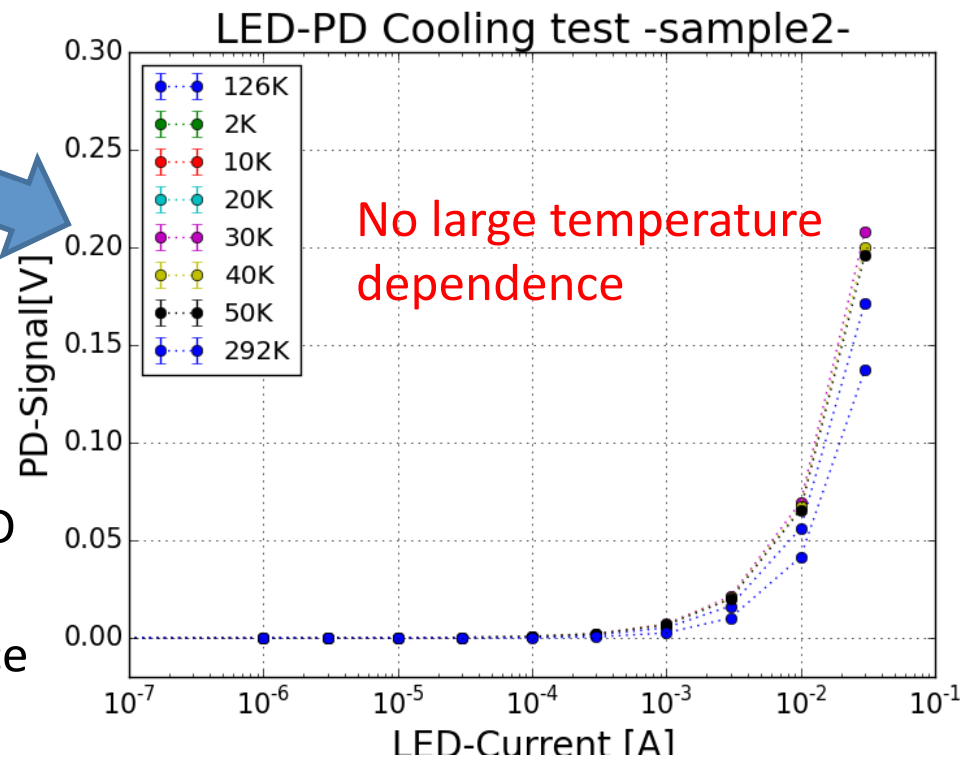
These will be reflected to remaining 3 payload fabrication in this year.

Local Displacement Sensor

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



We found a combination of PD and LED worked in low temperature. Statistical check of PD-LED performance is under performing.

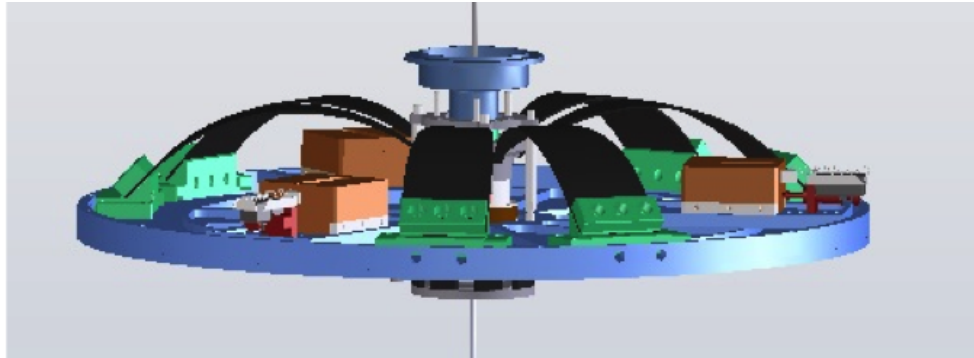


Digital system in KEK

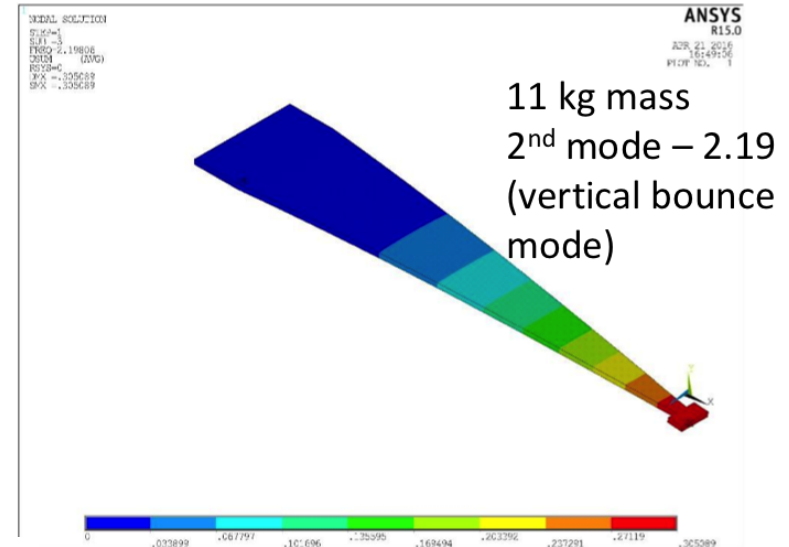
- A digital control system used in NAOJ to test Type-B vibration attenuation system was moved to KEK to built Cryo-Payload control model.



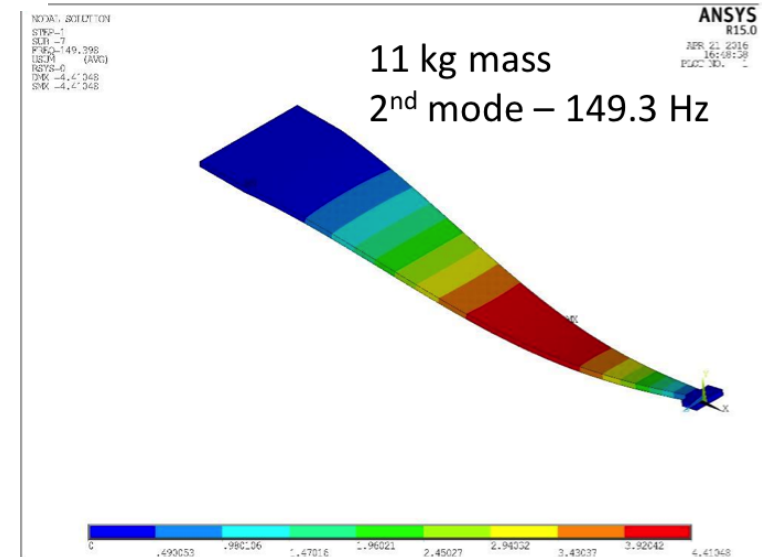
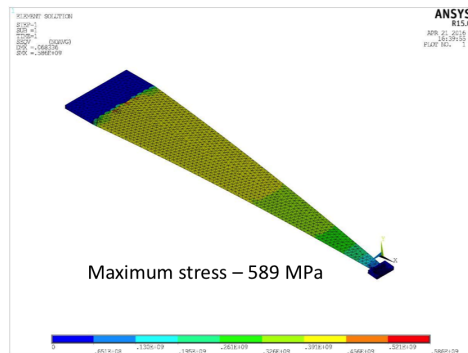
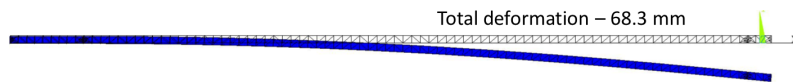
Study of Material Properties at Cryogenic Temperature



BeCu blade-springs are used in the platform.
We plan to use simple blade-spring.

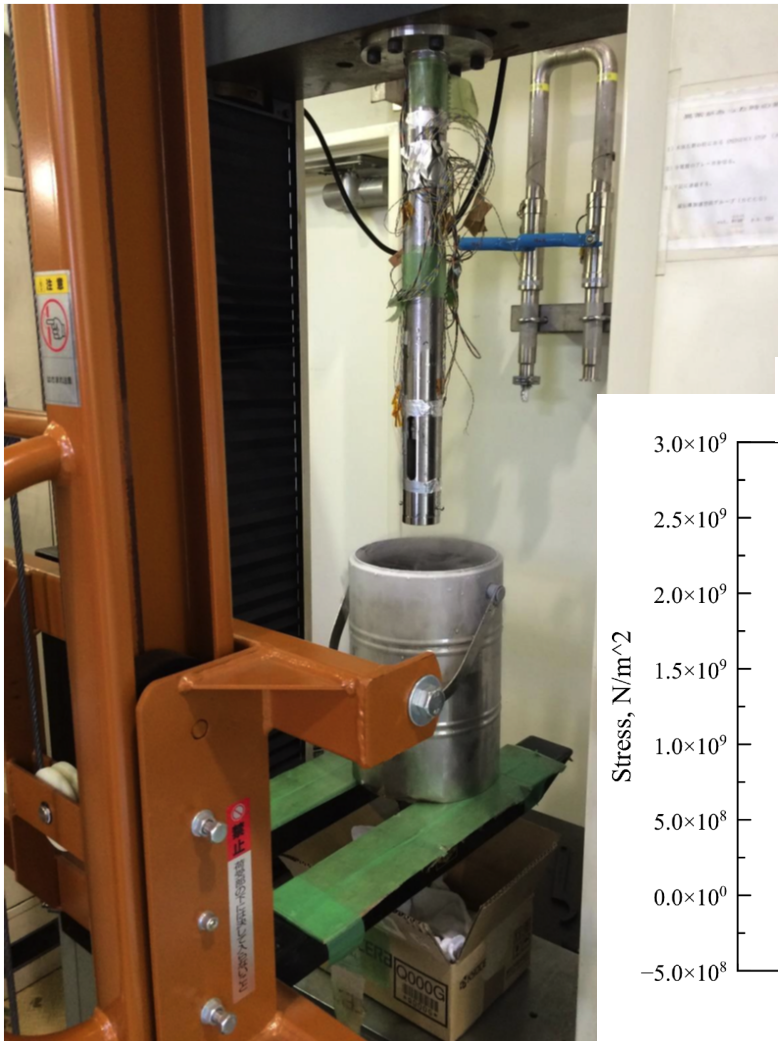


ANSYS simulation for blade-spring at room temperature



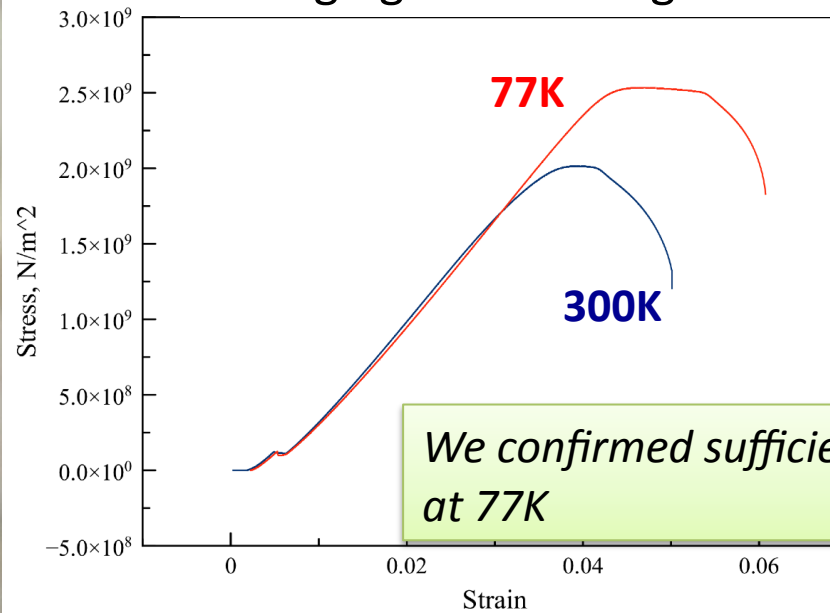
Measurement of Young's modulus at cryogenic temperature is under performing in KEK

Strength Test of wire/blade materials at cryogenic temperature



BeCu strength is also under doing.

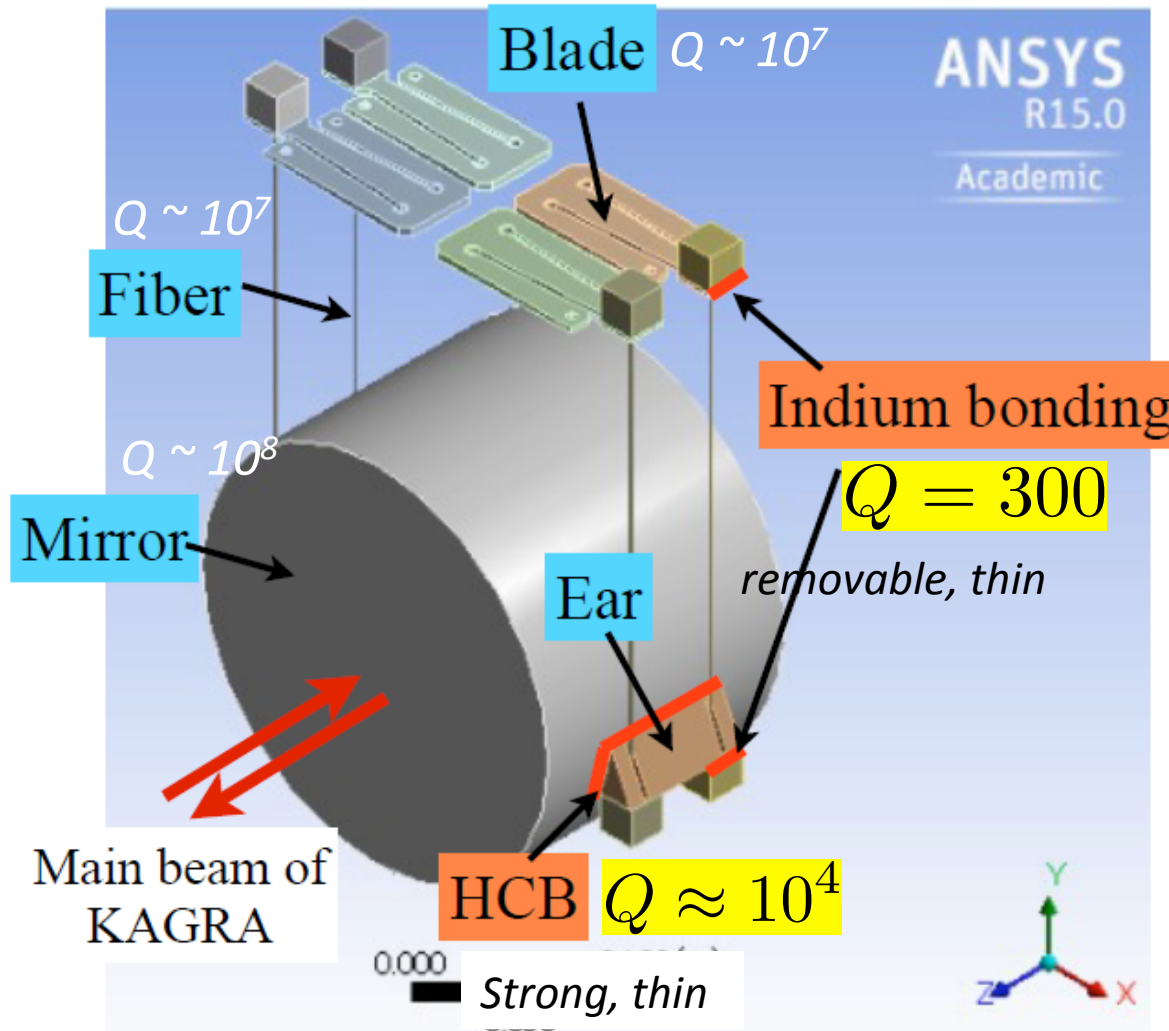
Maraging Steel Strength Test Result



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

We confirmed sufficient strength at 77K

Hydro-Catalysis Bonding (HCB) and Indium Bonding on Sapphire



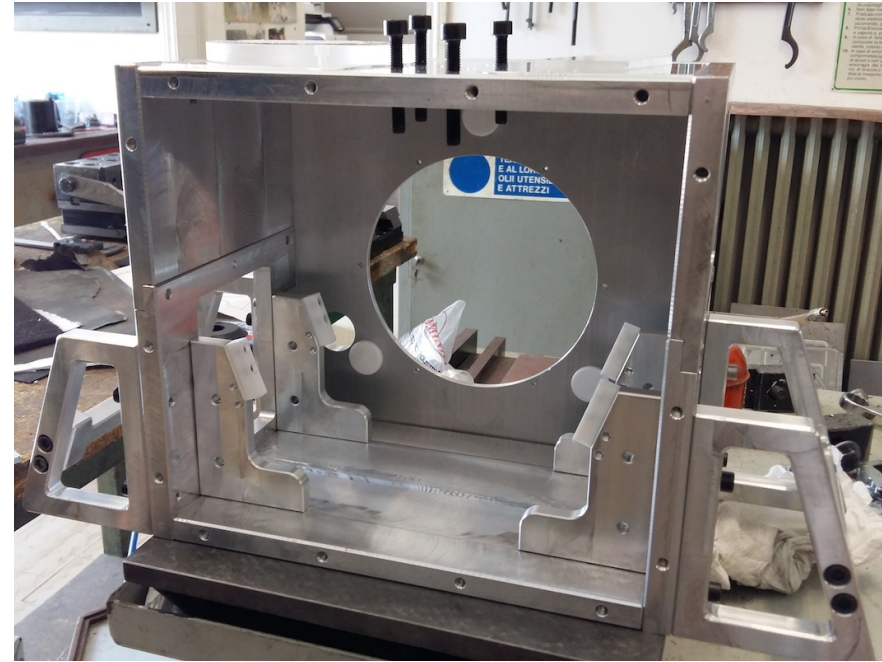
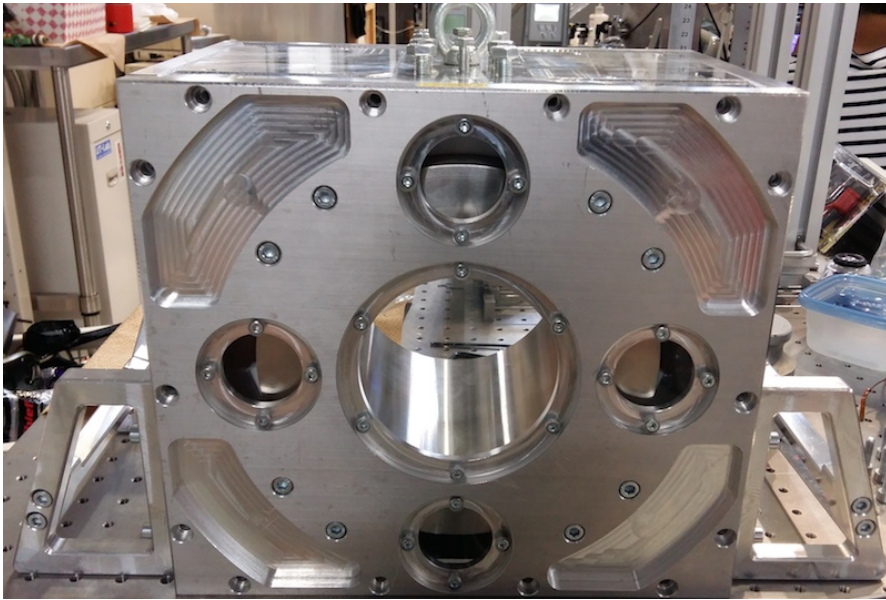
Semi-monolithic sapphire suspension must be realized to be sufficiently small thermal noises.

HCB and Indium bonding on sapphire satisfies requirements of mechanical Q.

Practical way to do these bonding is under testing.

HCB Bonding Jigs

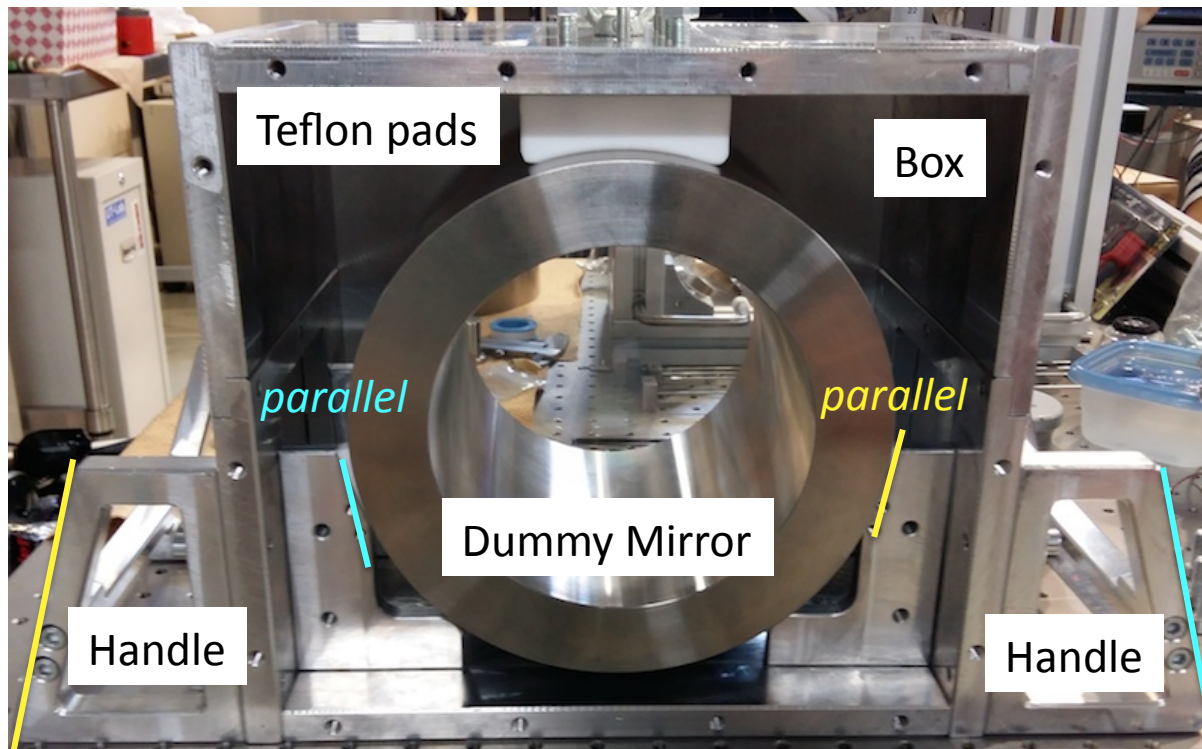
- The jigs for ear positioning during HCB bonding are incorporated into a box, which may also be used for transport and to support the mirror during suspension
- This is same way as aVIRGO.
- Perugia Univ. fabricated this KAGRA box and it is in our hand now.



HCB / Mirror Transportation Box for KAGRA

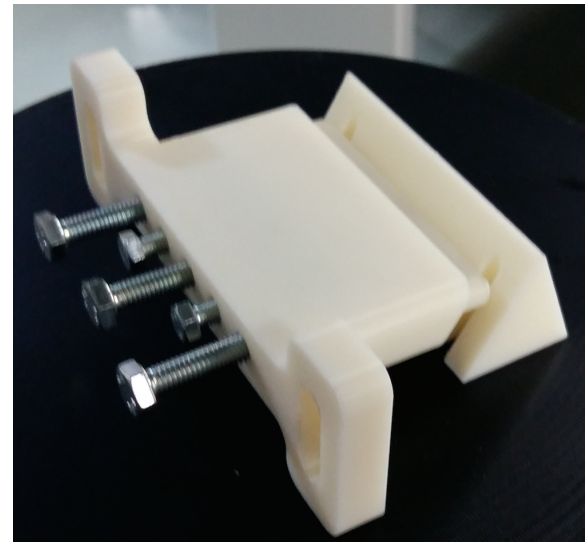
HCB Bonding Jig

- 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
- Glasgow style HCB (silicate bonding) will be applied.

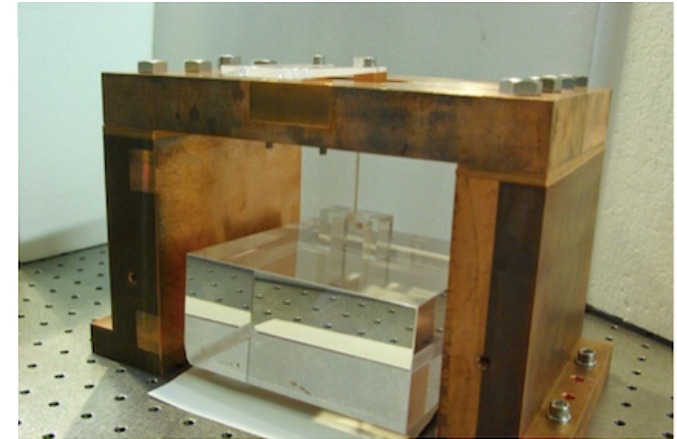
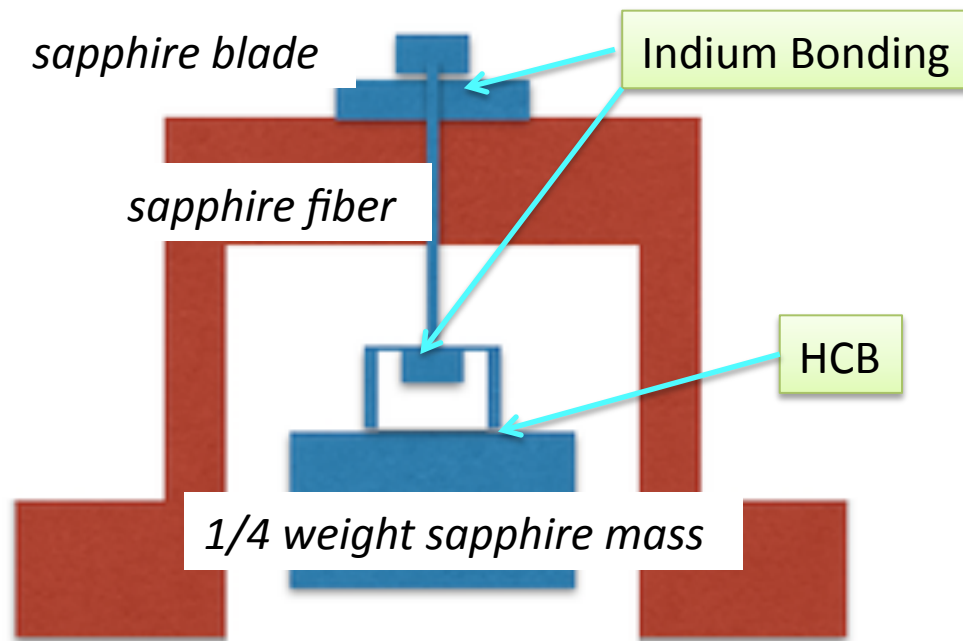


HCB jig testing

- 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



Demonstration by one fiber prototype



- Technical feasibility was demonstrated.
- Thermal resistance and mechanical Q are under measurement
- Installation jig of fibers is under designing.

Schedule for Sapphire Suspension Development

- 2016. 7 - 8 HCB on prototype sapphire mirror
- 2016. 9 Indium bonding on prototype sapphire
- 2016. 10 Cool down test
- 2016. 11 – 12 Q measurement
- 2017. 2 HCB on ETMs
- 2017. 3 Indium bonding on ETMs
- 2017. 4 - 8 Cryogenic test of ETMs
- 2017. 8 Assembly of sapphire parts ITMs
- 2017. 9 - 10 ETMs installation into cryogenic payload

Summary

CRY sub-group does our best to be in time for bKAGRA-1 and bAKGRA-2.