Cryogenic Sapphire Mirror Suspension System for KAGRA Detector

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sented at the 12th Edoardo Amaldi Conference on Gravitational Waves, 9 – 14 July 2017, Pasadena, California, U

Outline

Introduction: KAGRA project – see Seiji Kawamura's talk

Cryogenic payload system

Sapphire suspensions

Conclusions


enoyama
KAGRA Detector
(Large Scale Cryogenic Gravitational Wave Telescope)
Arm length 3 km
200 m
underground site

Unique features of KAGRA

nderground site for the detector

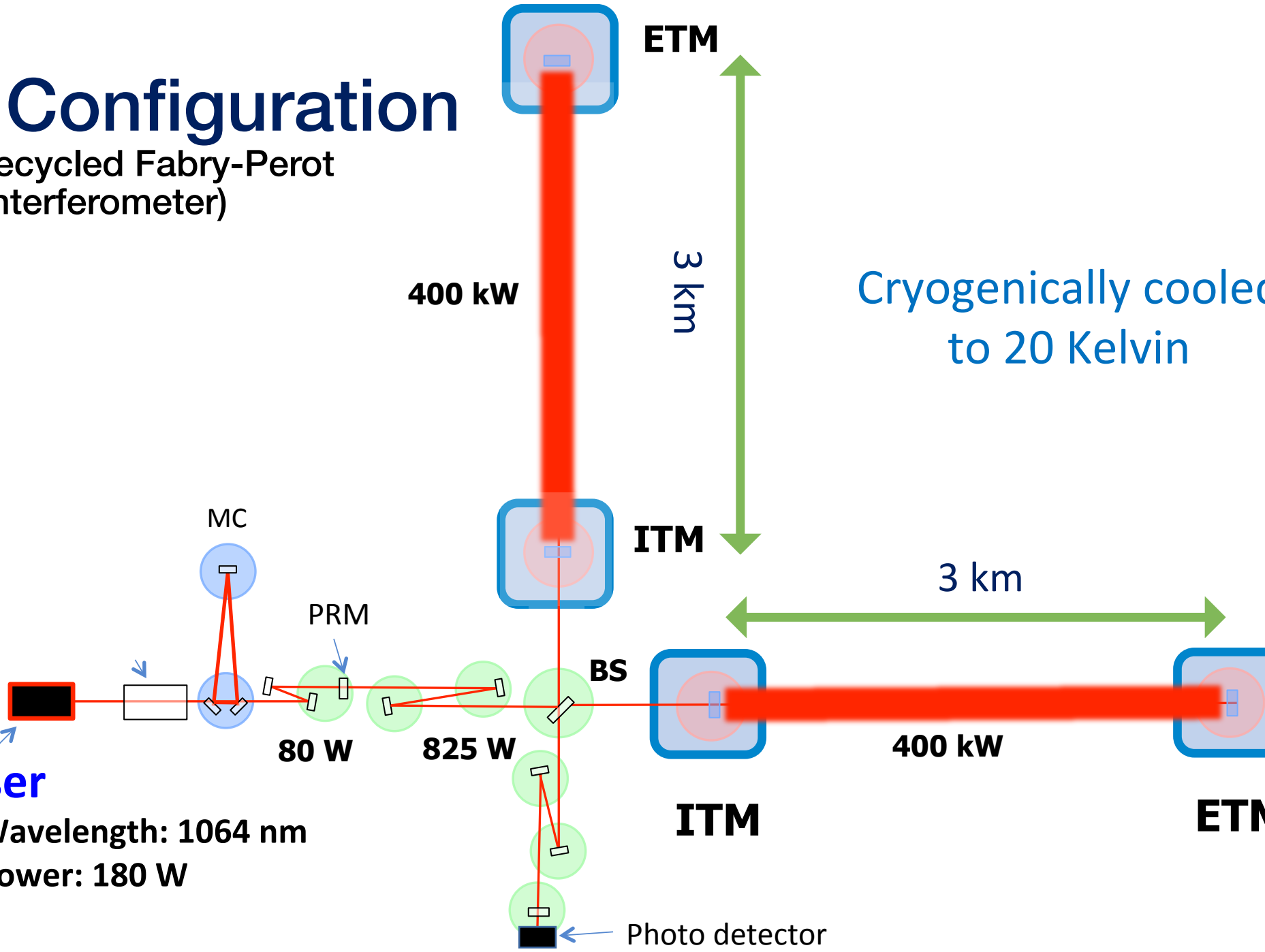
ces seismic noise

Cryogenic technologies

duces thermal noise in the mirrors and
spensions of the interferometer

ptical Configuration

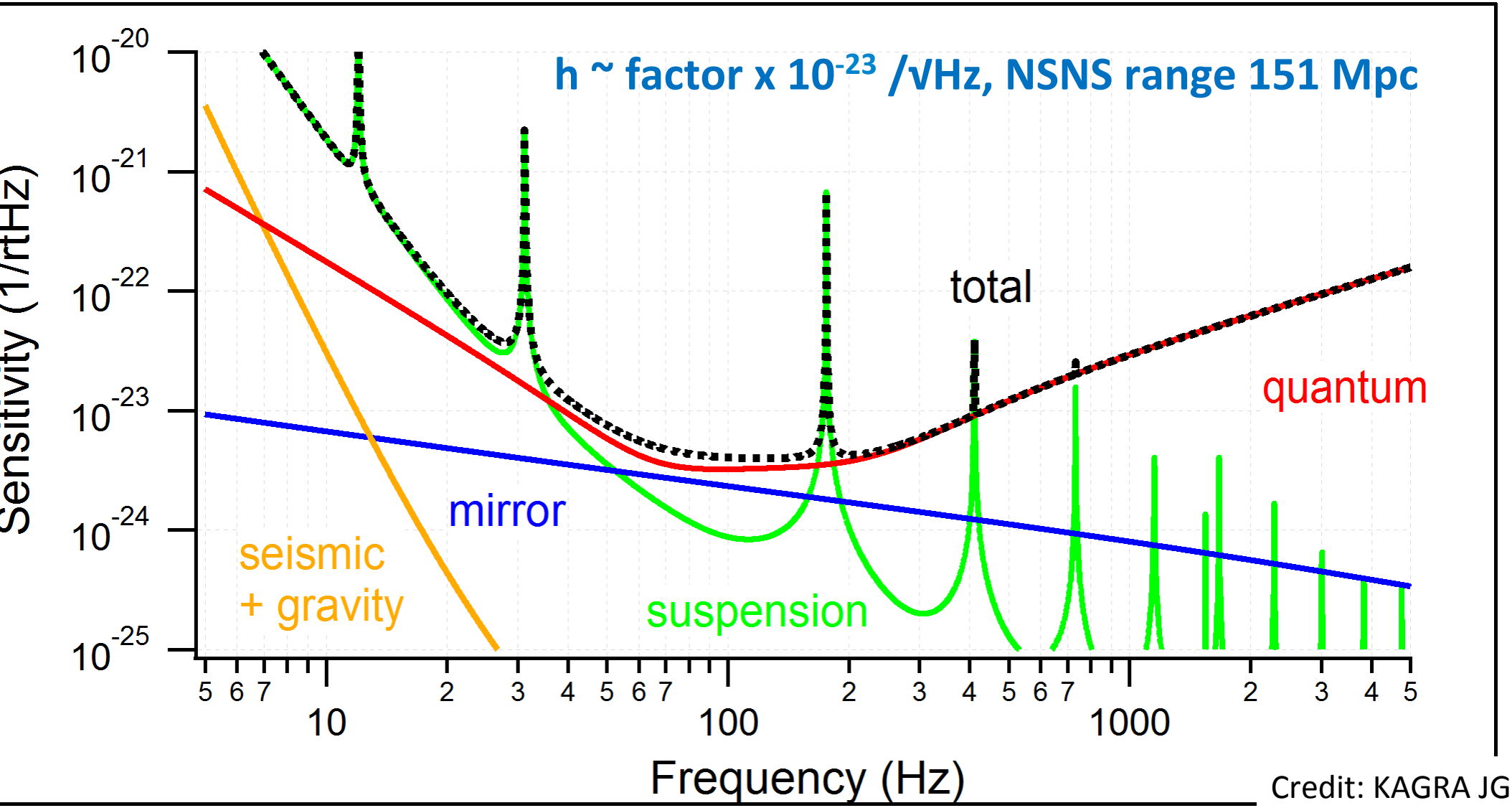
(Dual Recycled Fabry-Perot Interferometer)



Laser

- **Wavelength: 1064 nm**
- **Power: 180 W**

Baseline Sensitivity



Credit: KAGRA JG


X-arm of the KAGRA detector


Cryo-duct and Cryostat for ITM-X
VIS duc
KEK
WAKAI
SP 250

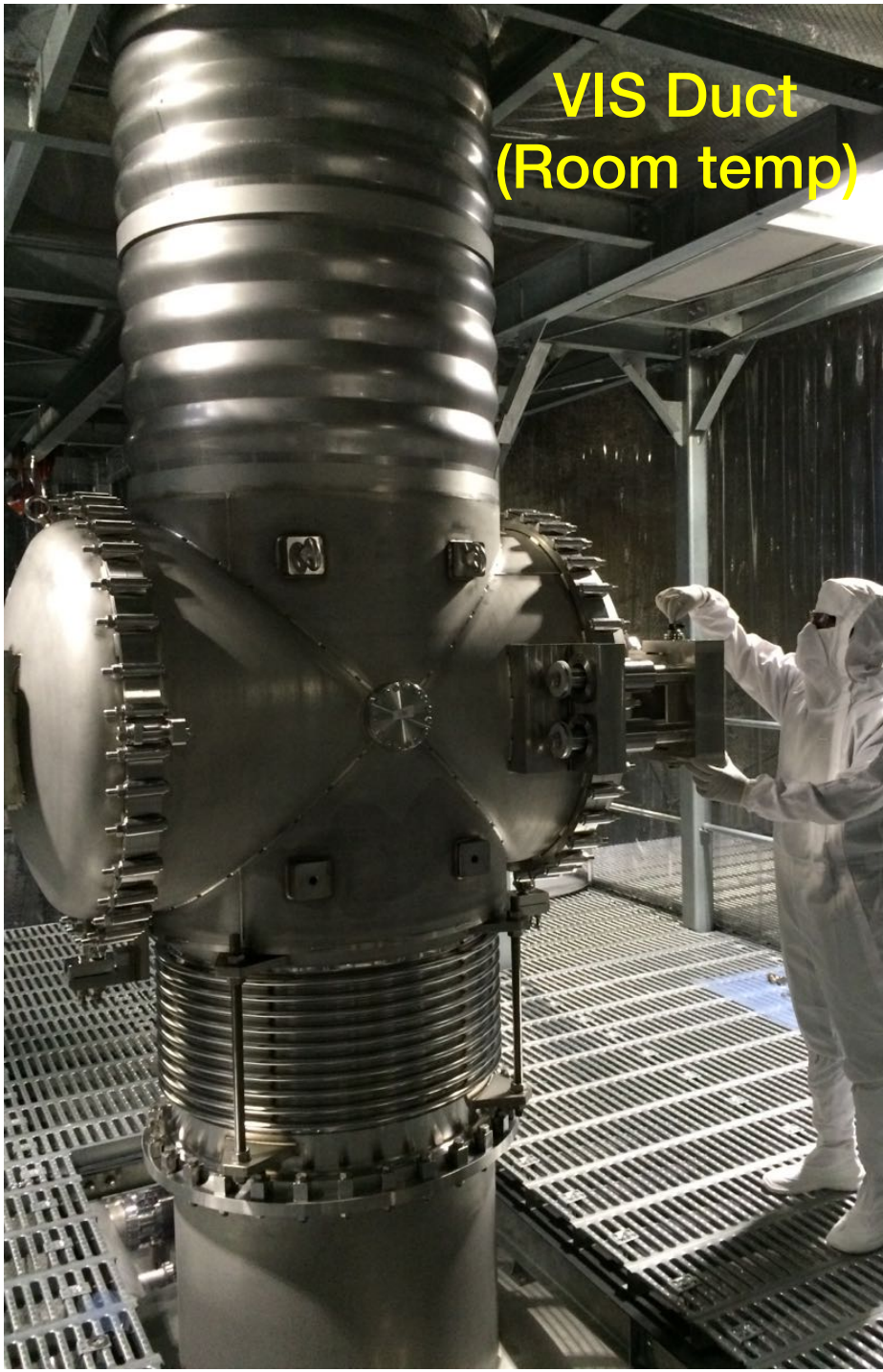
Vibration isolation system (VIS)

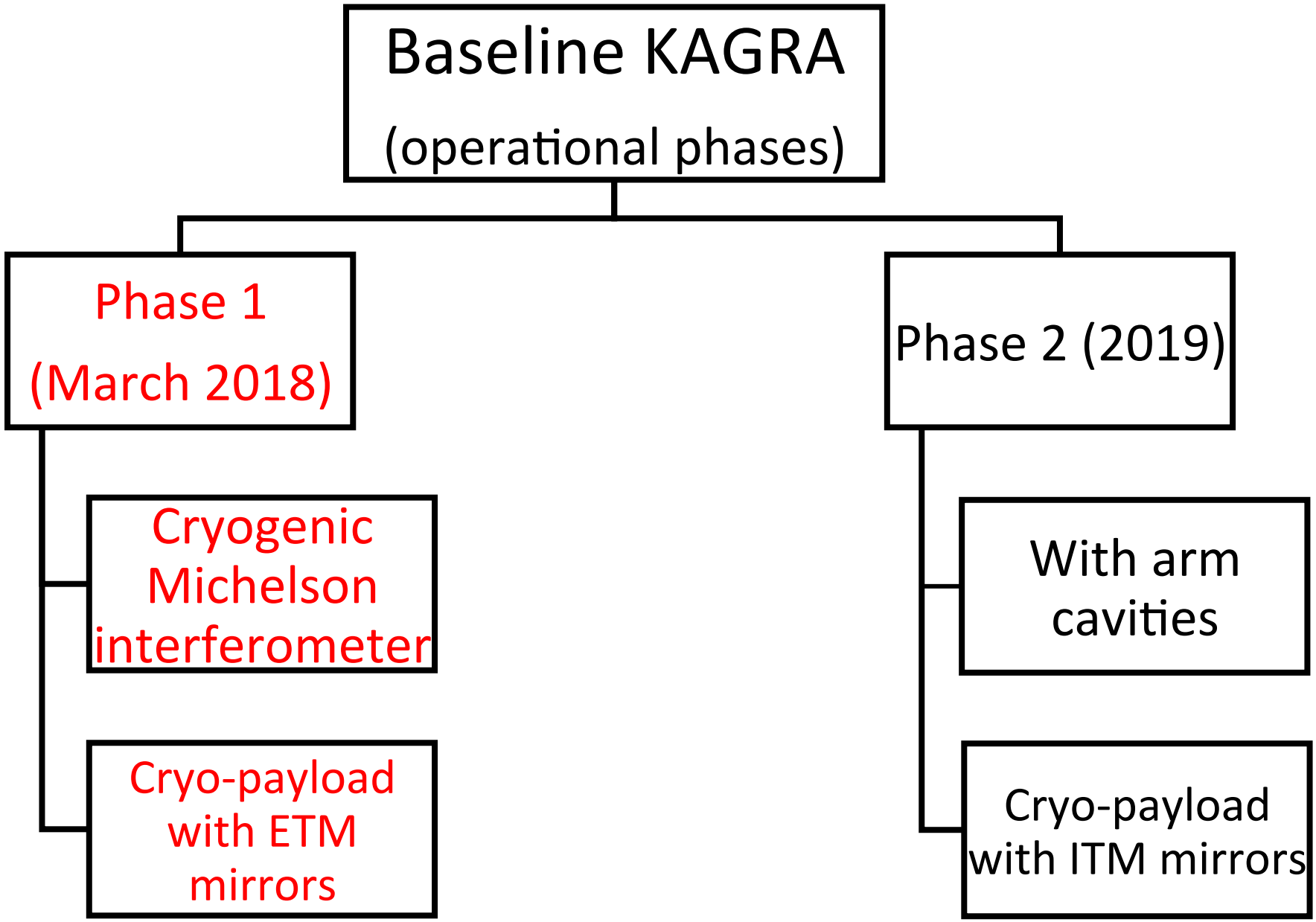
Room temperature

Height 14m

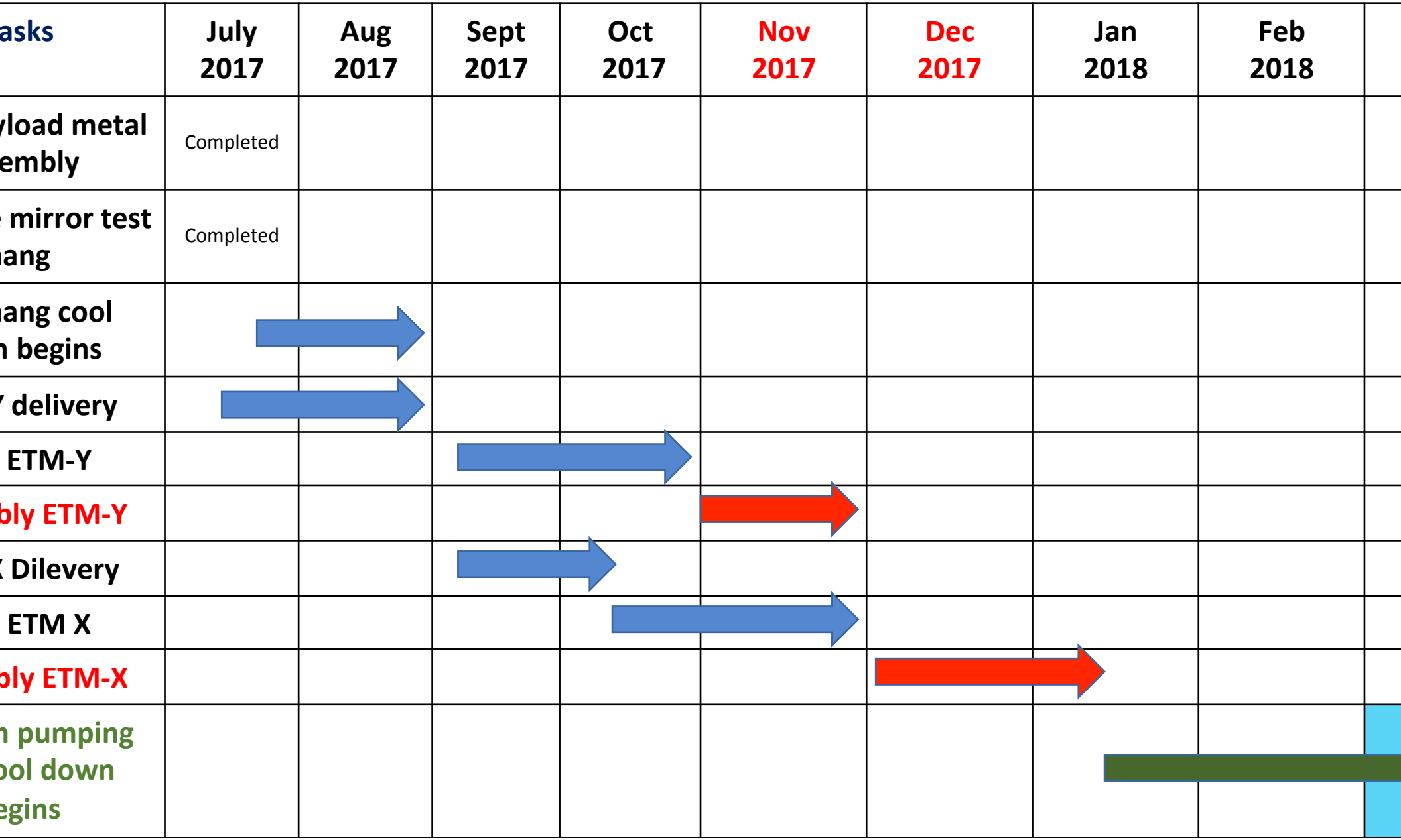
Cryo-duct

Cryo-coolers

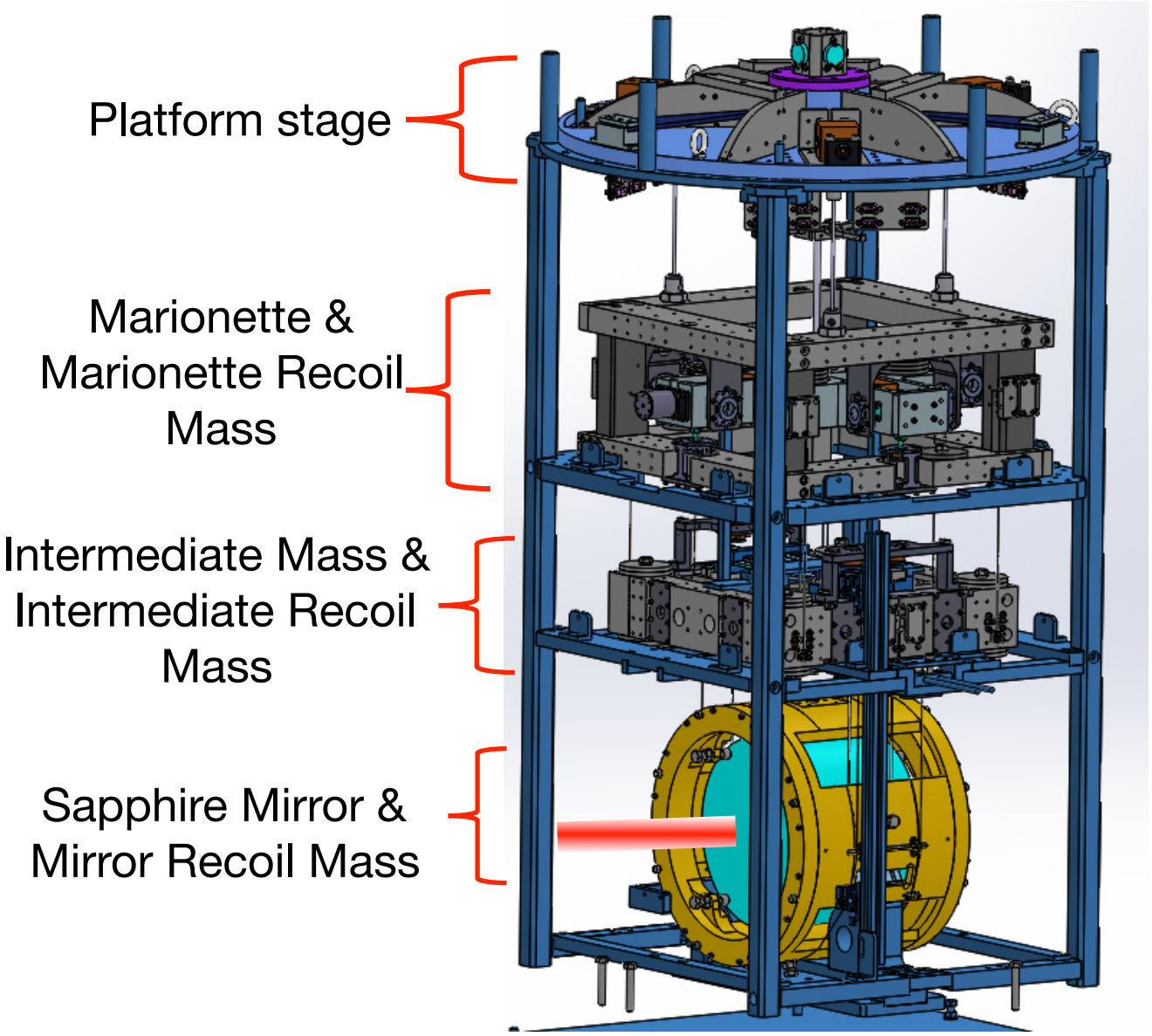



Baseline KAGRA
(operational phases)
Phase 1
(March 2018)
Phase 2 (2019)
Cryogenic Michelson interferometer
Cryo-payload with ETM mirrors
With arm cavities
Cryo-payload with ITM mirrors

Cryo Group's Schedule: bKAGRA phase 1



Cryogenic Payload System



200 kg paylo

Operational tem

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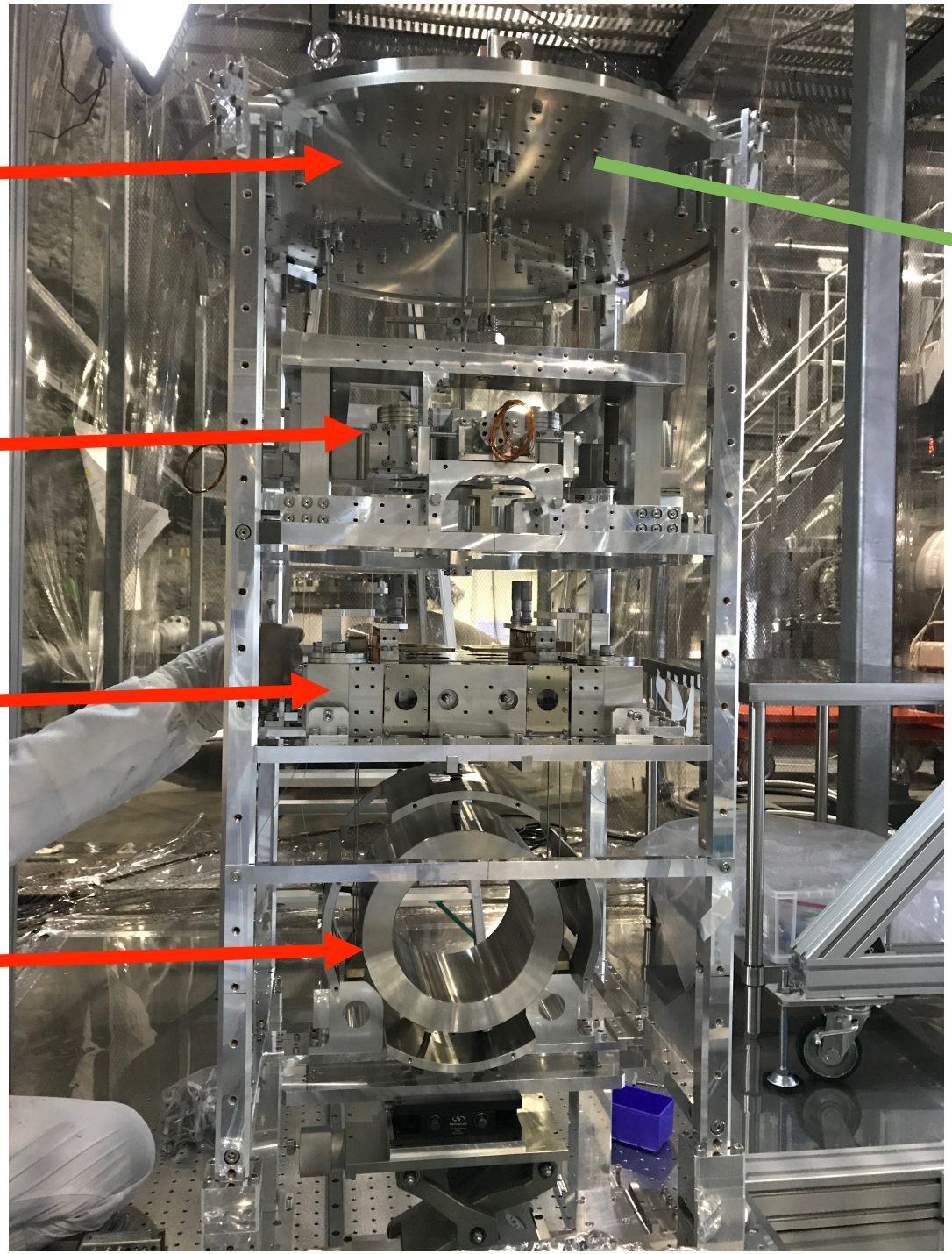
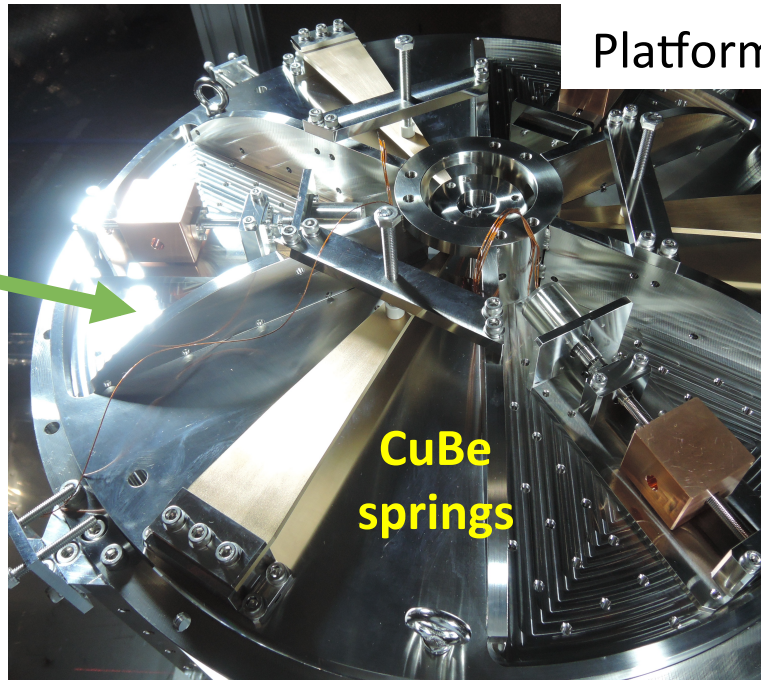
kg



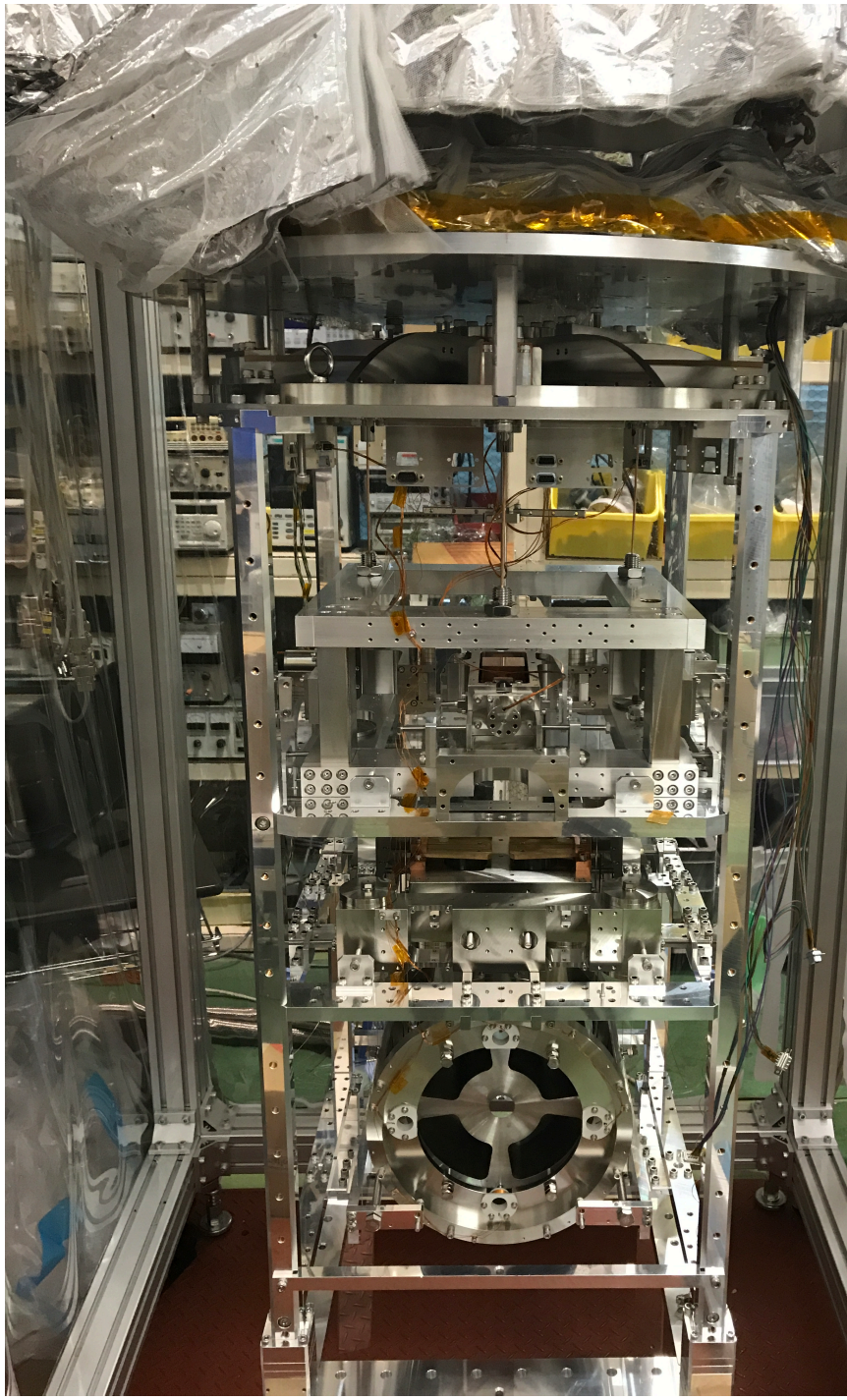


All metal cryogen
payload assembled
KAGRA site

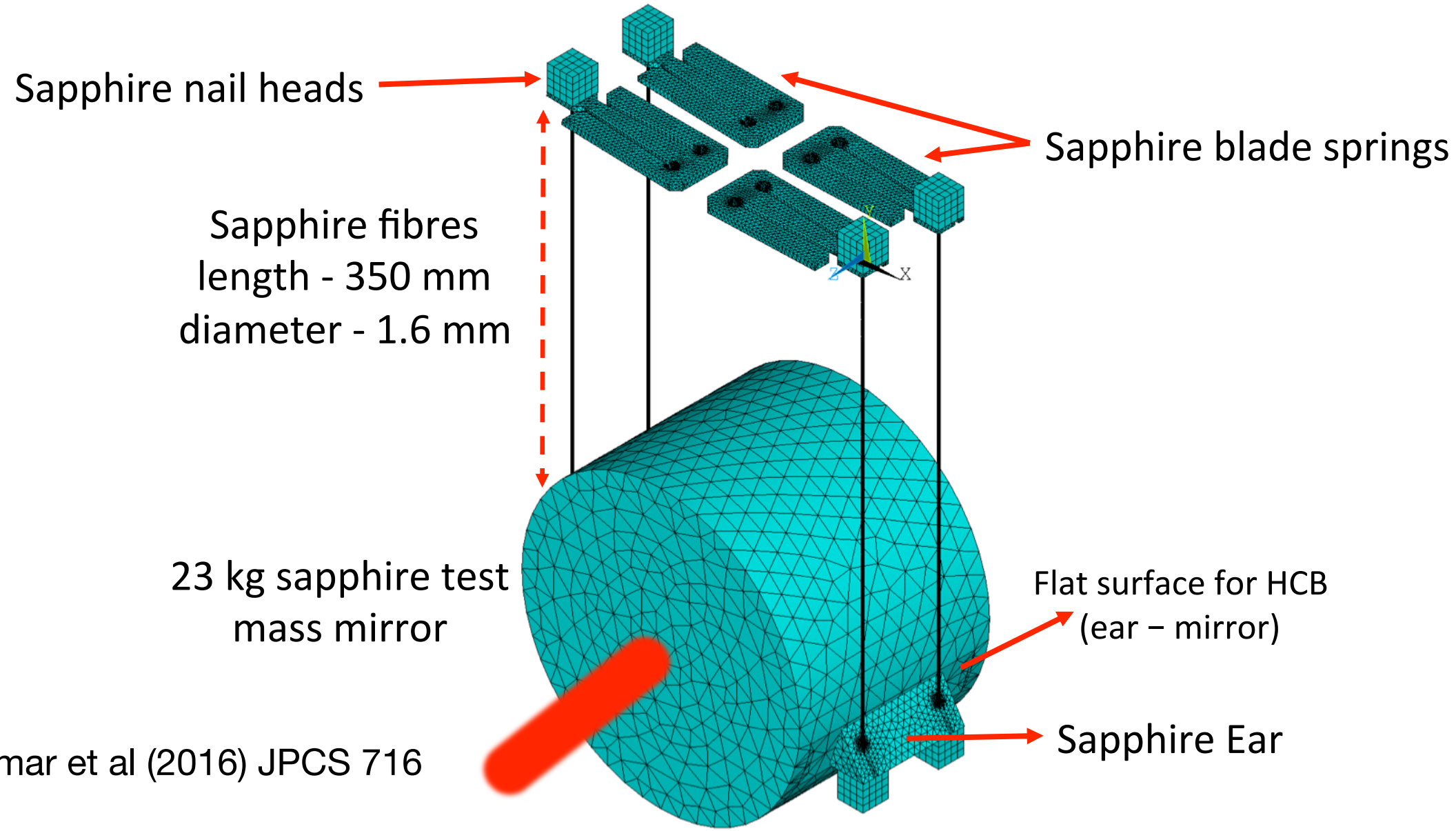
- Will be suspended from
VIS system

At KEK we assembled a stand alone (no VIS)
ll metal cryogenic payload system
This is currently in a cryostat undergoing cool
own test
We are testing for control, heat load and DAQ
ystem

ryo-payload inside ¼
KAGRA size cryostat



Sapphire Suspension System

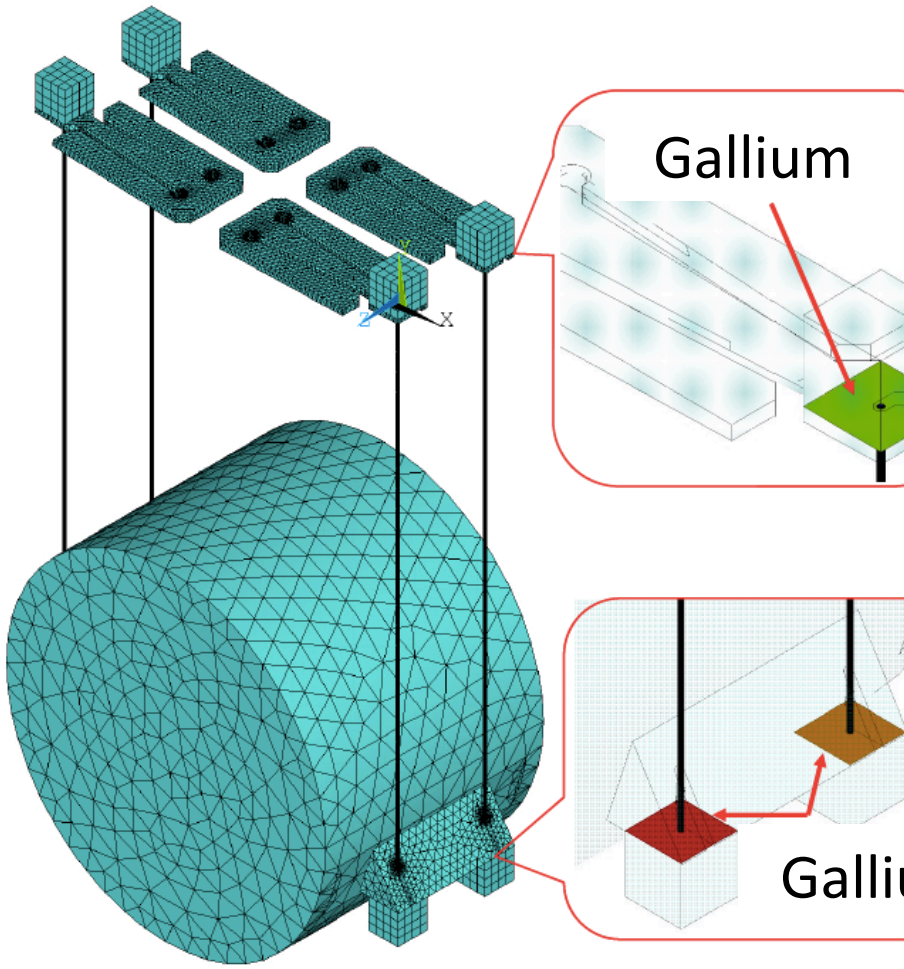


Jointing of Sapphire Components

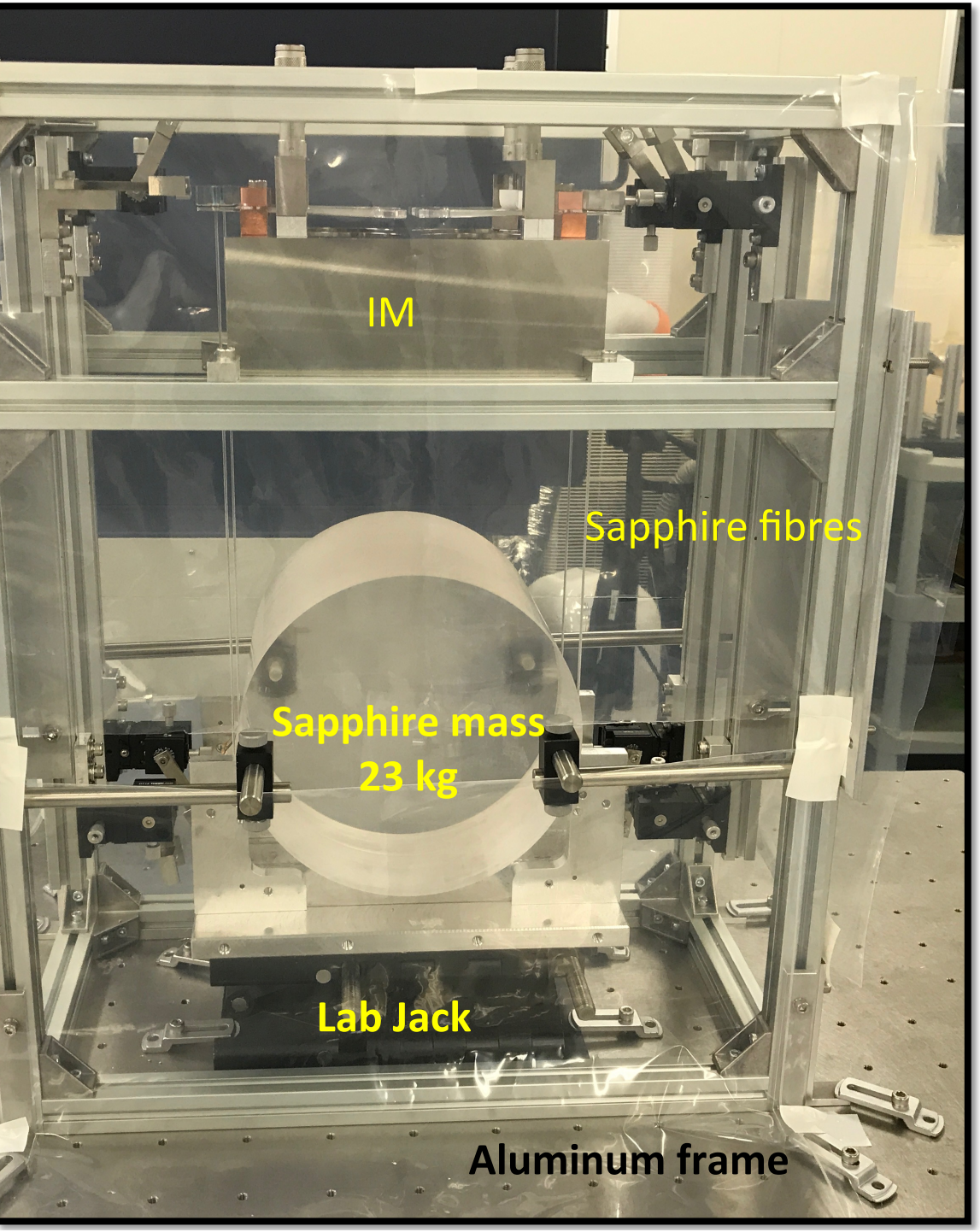
iginally Indium (melts at 160^0 C) was the oice for the weld material

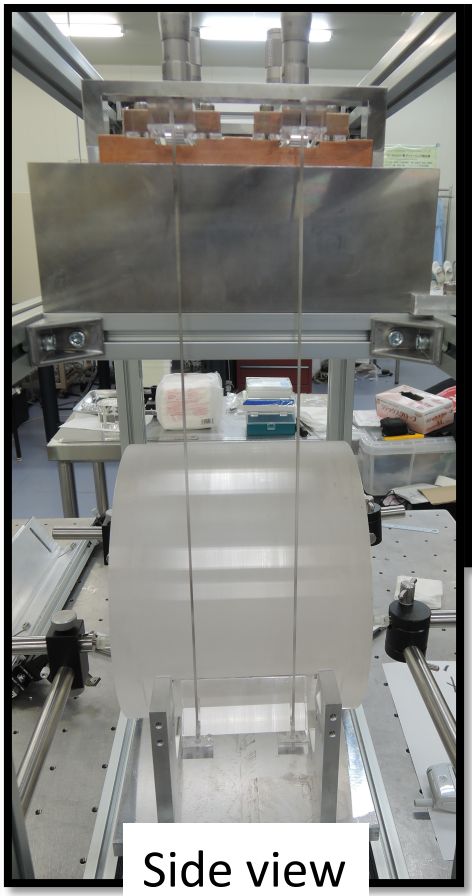
wever, we are also studying the use of llium as bond layer

- Gallium melts at 30^0 C
- Sapphire-Gallium shear strength – 20 MPa

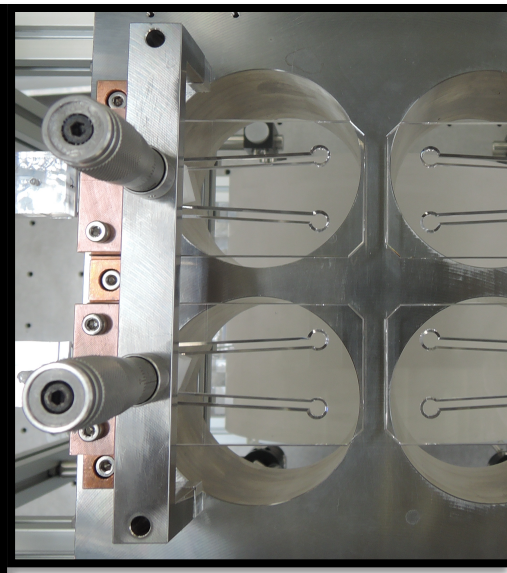


We assembled the 1st proto sapphire suspension syst at KEK in May 2017





Side view



Sapphire blade sp

After successfully assembling the 1st prototype suspensions we decided to assembly the 2nd sapphire test suspensions at the KAGRA site for cool down test in a cryostat

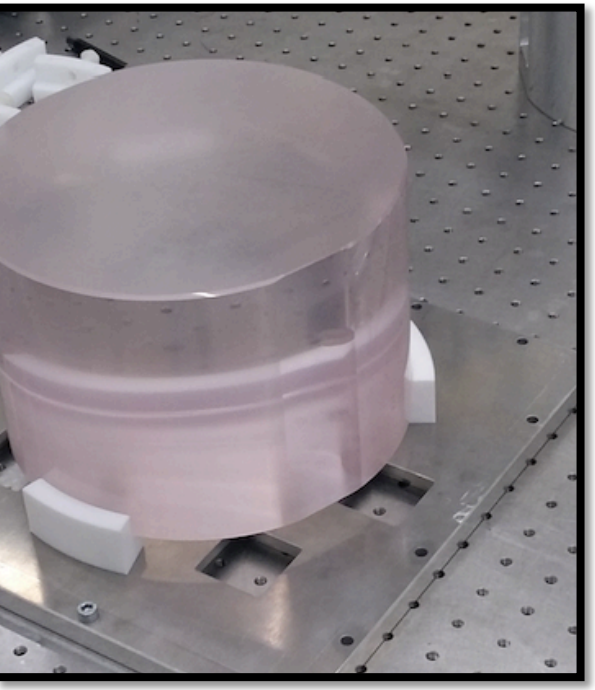
We used 23 kg Coastline Sapphire Test Blank (STB) mirror for the 2nd assembly

HCB (Hydroxide Catalysis Bonding technique) of the Coastline mirror to ear was performed at Toyama University

- Technique developed in University of Glasgow, U.K.
- HCB work in KAGRA is being led by K. Craig, H. Vocca, T. Ushiba et al.

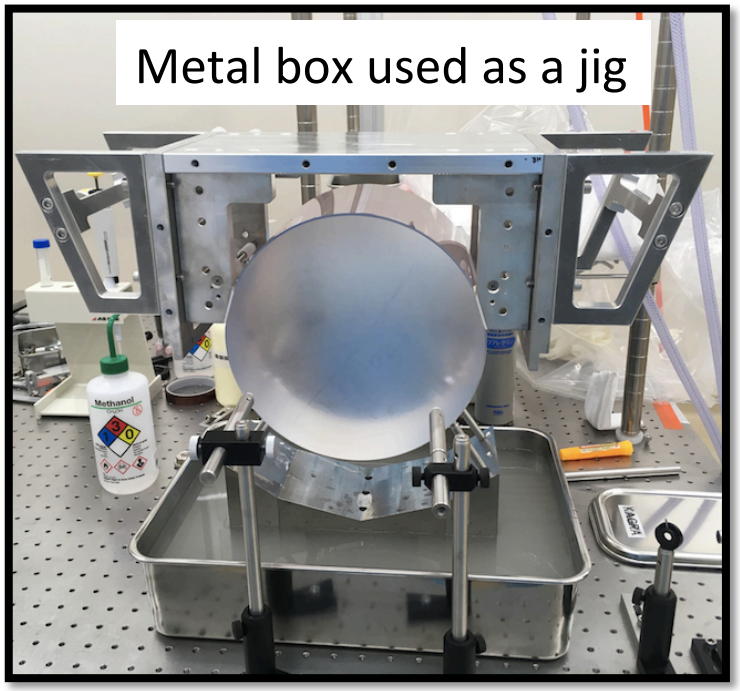
HCB of Sapphire Mirror

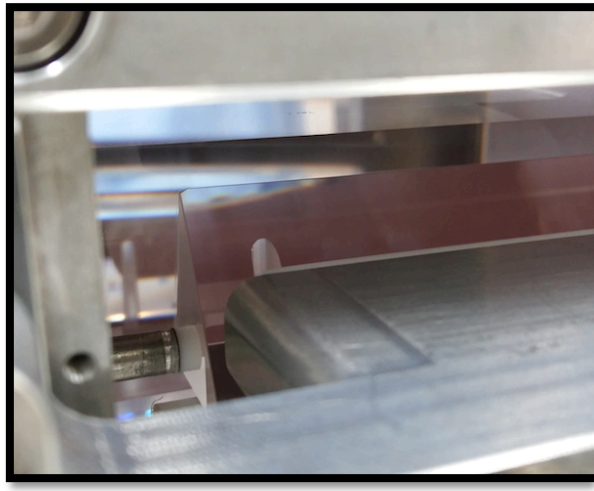
K. Craig, H. Vocca, T. Ushiba et al



apphire mass with side cuts

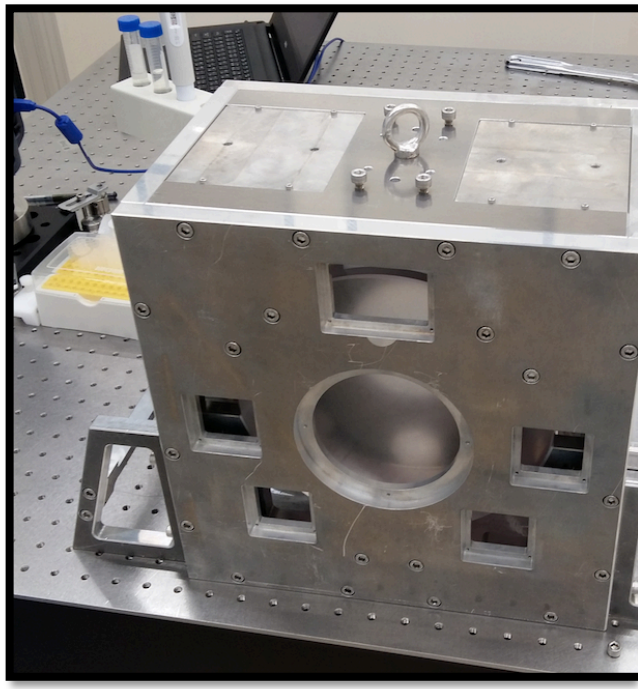
s for moving/handeling



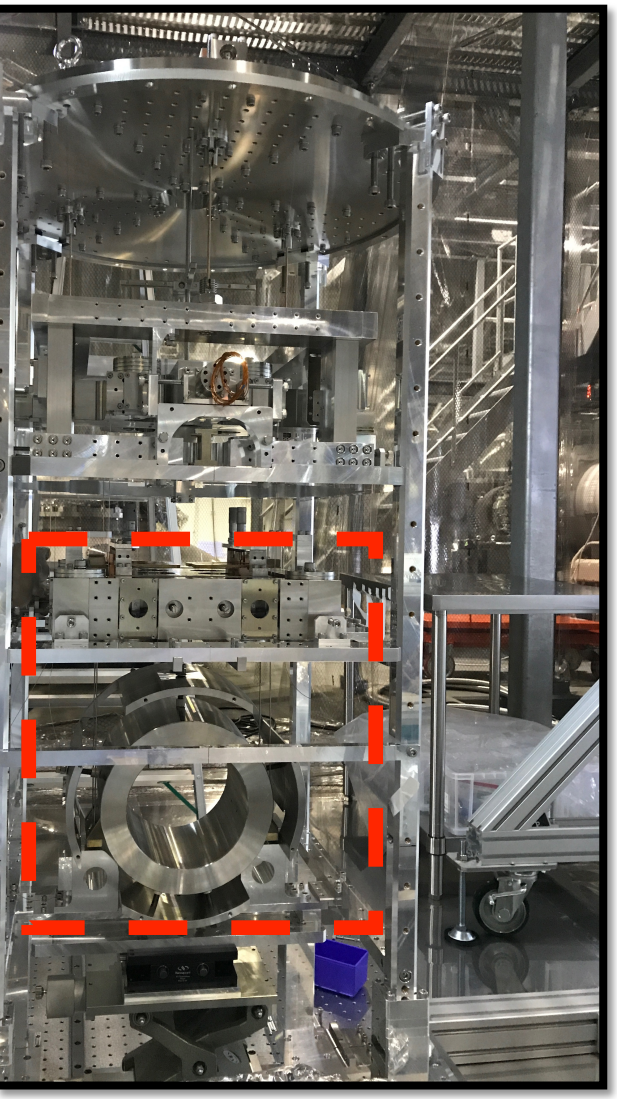


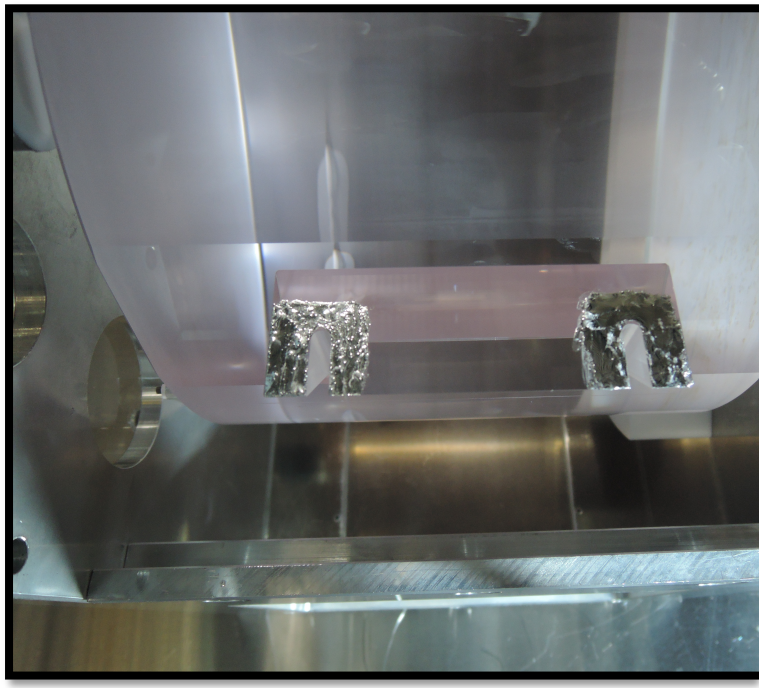
Sapphire ear bonded to sapp

Mirror box ready for transpo

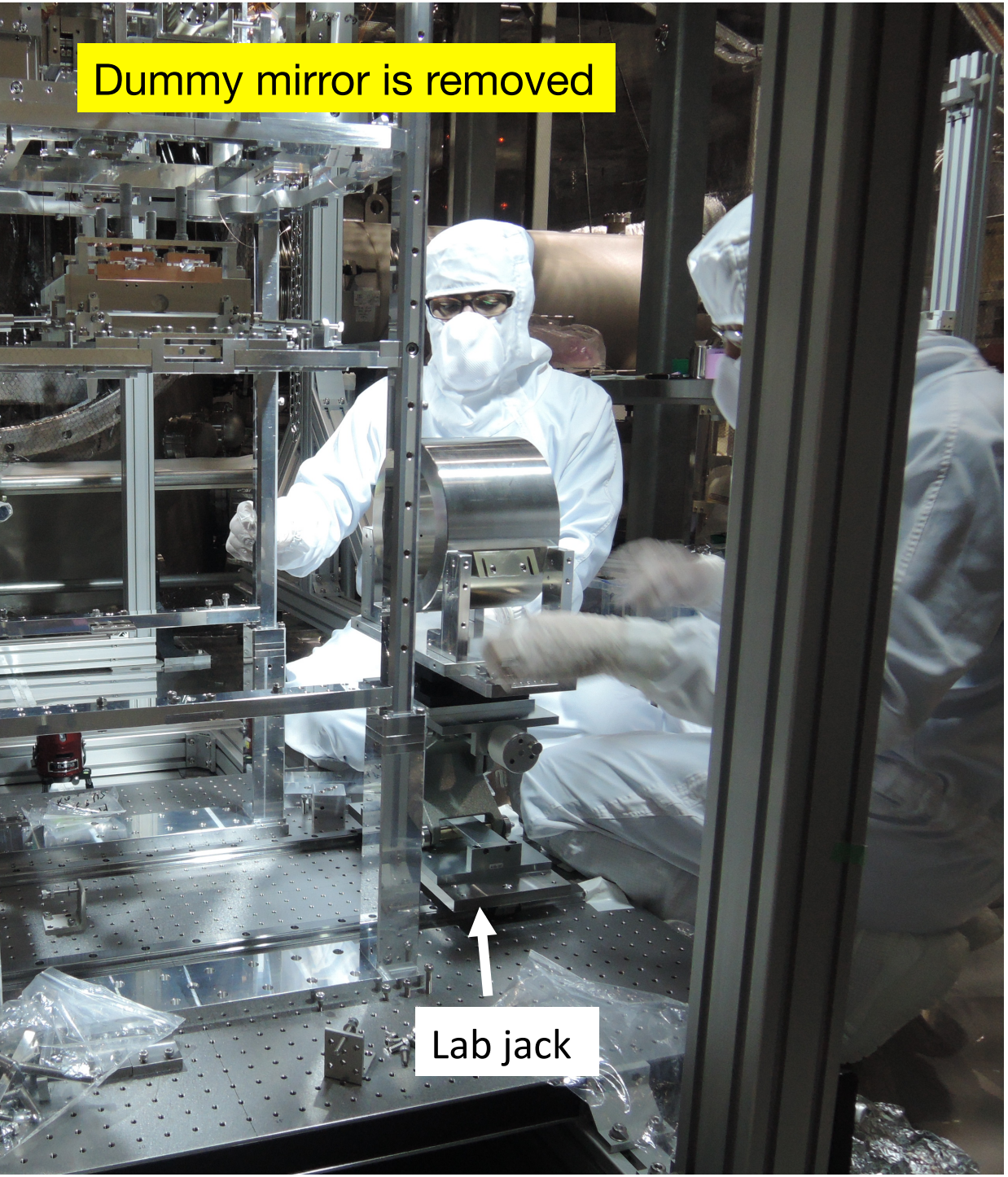


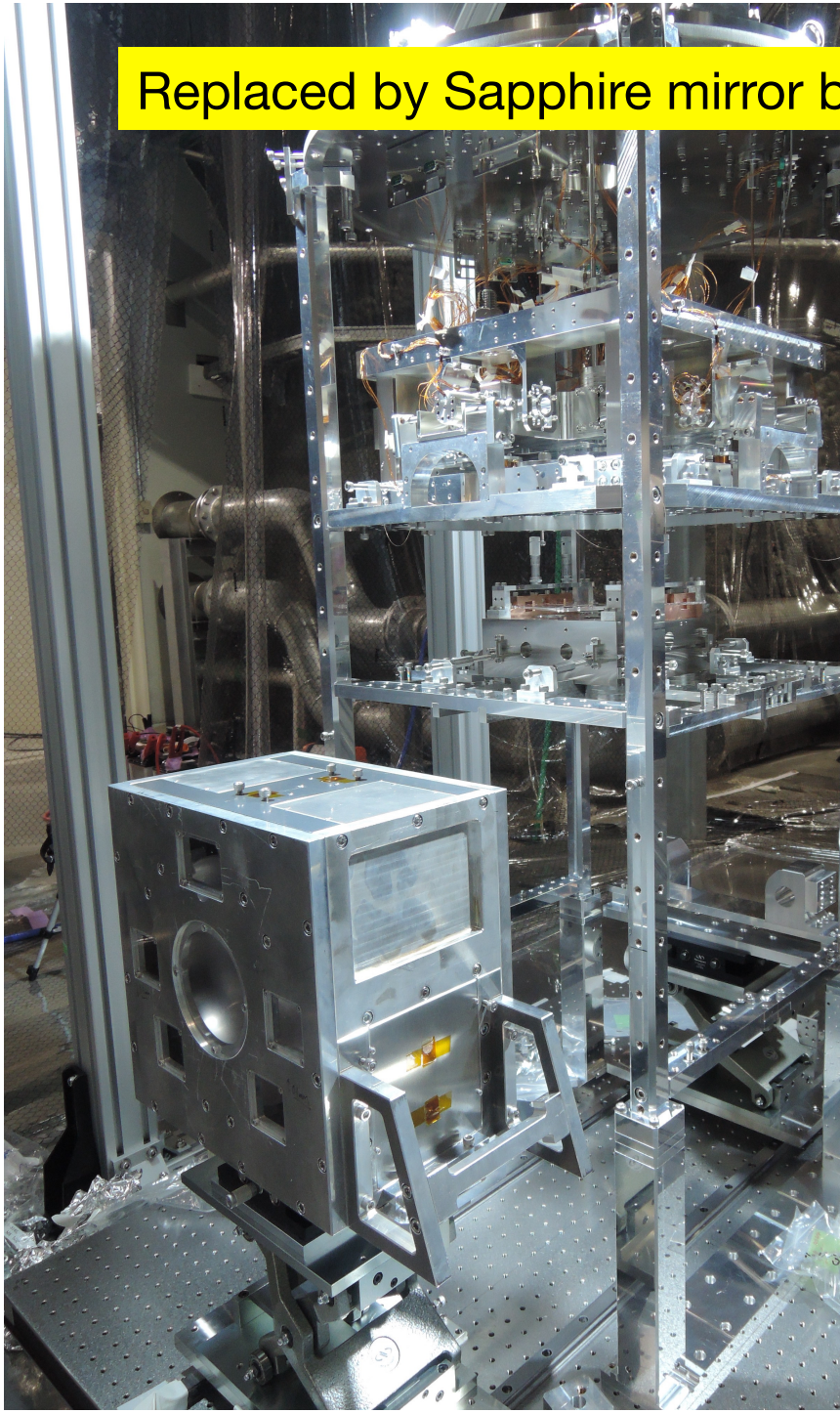
Assembly of sapphire suspension at KAGRA site



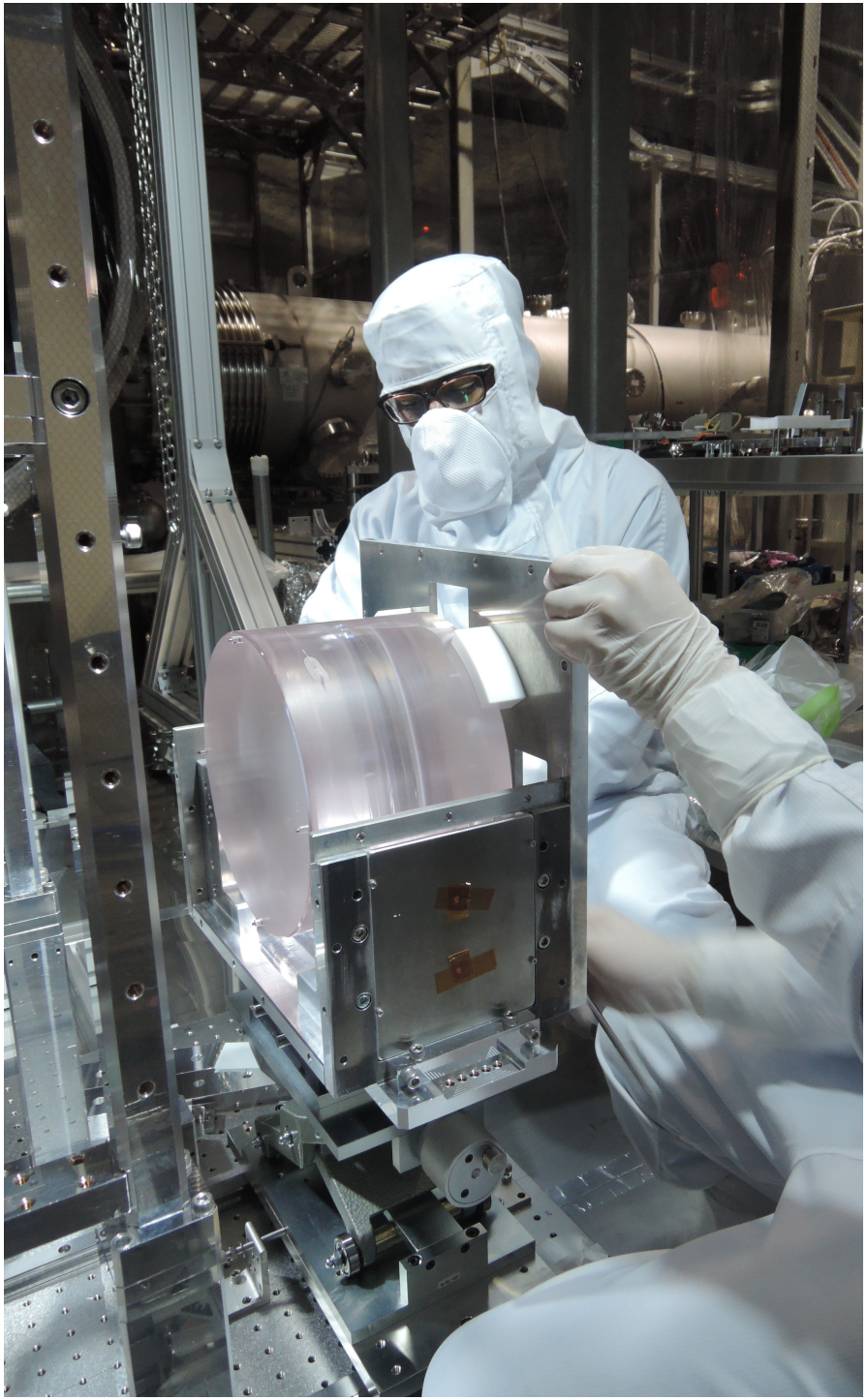


Depositing Gallium on the ears of the sapphire test mass mirror

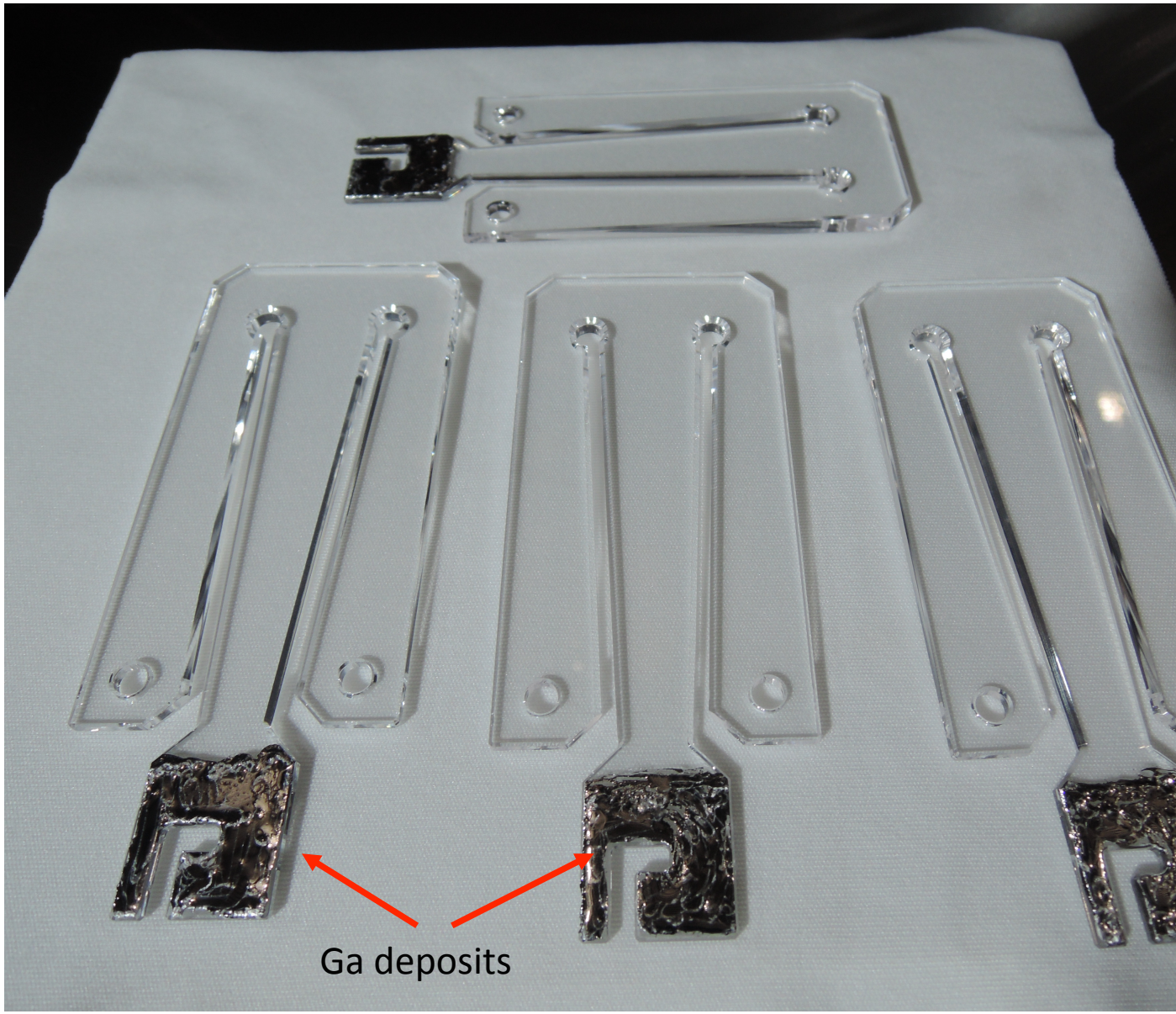

Dummy mirror is removed
Lab jack


Replaced by Sapphire mirror b

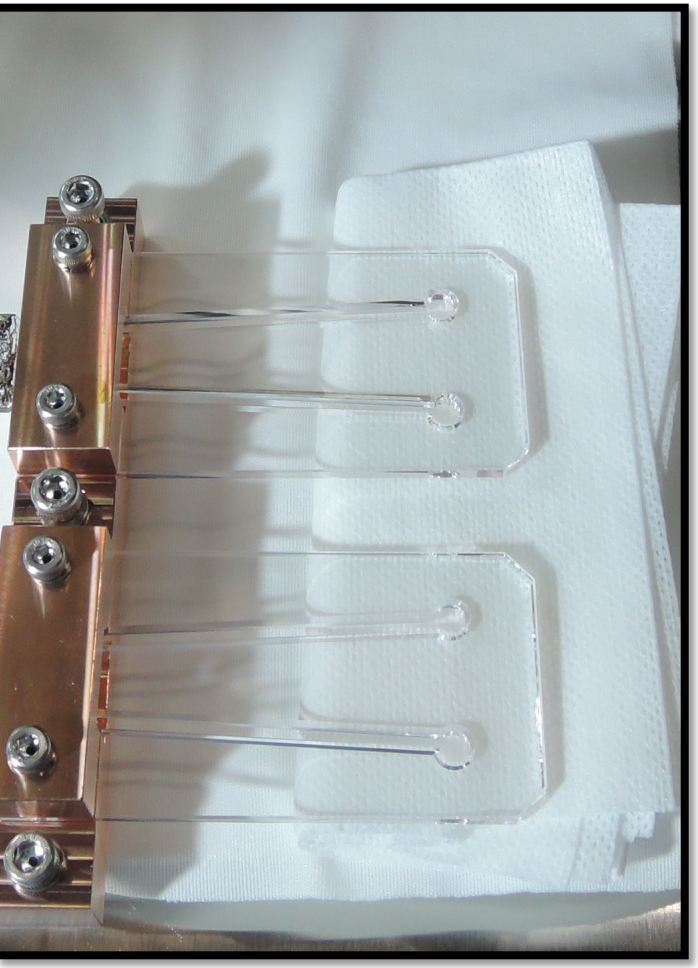
oxing of the sapphire mirror

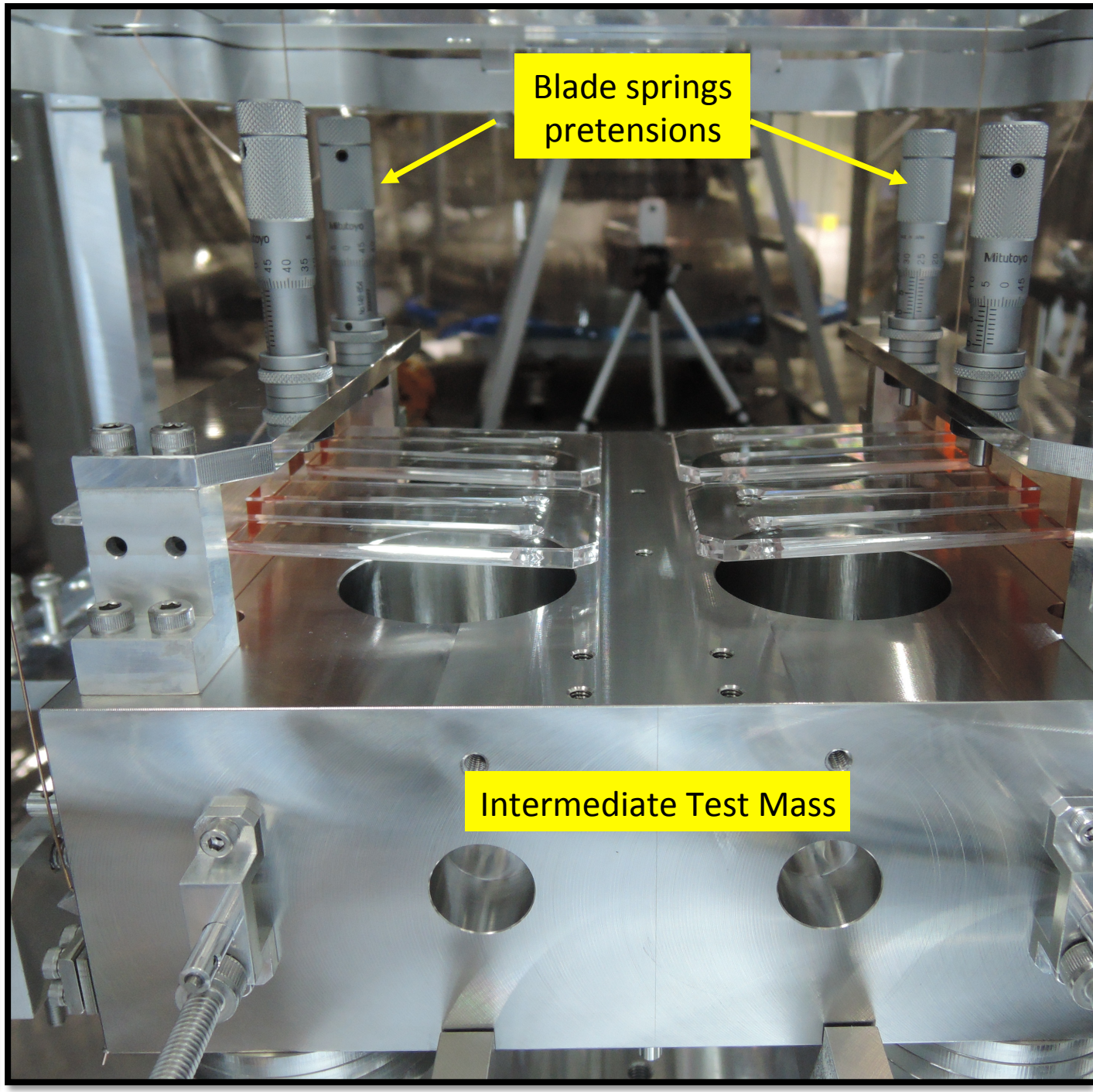


Ga deposition: sapphire blade springs

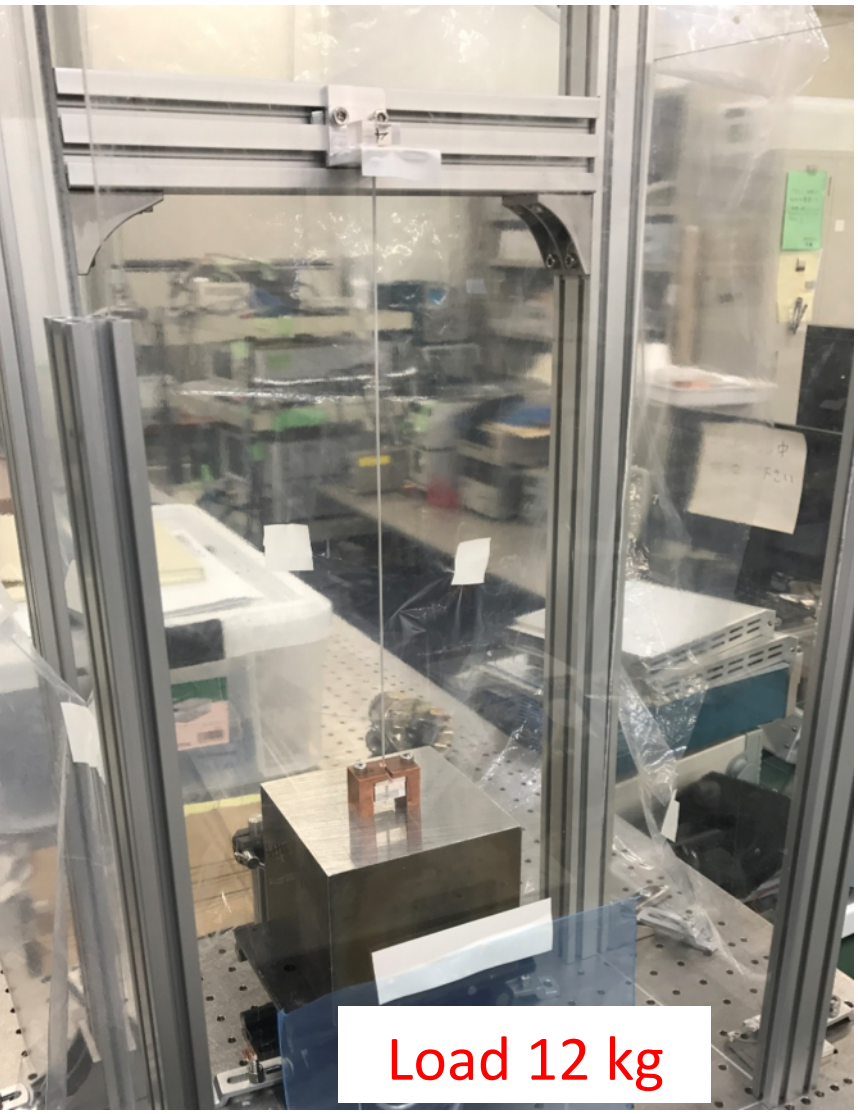


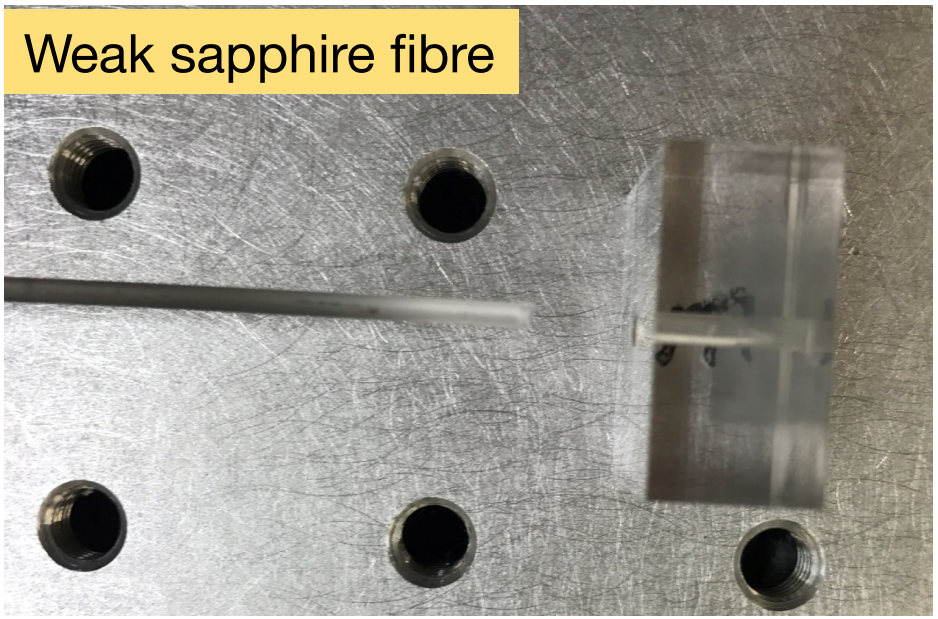
opper clamps for
phire blade springs





Sapphire Fibres Strength Test





Strong sapphire fibres (12 kg -1 hour) is selected for suspension assembly

Twice the minimum requirement

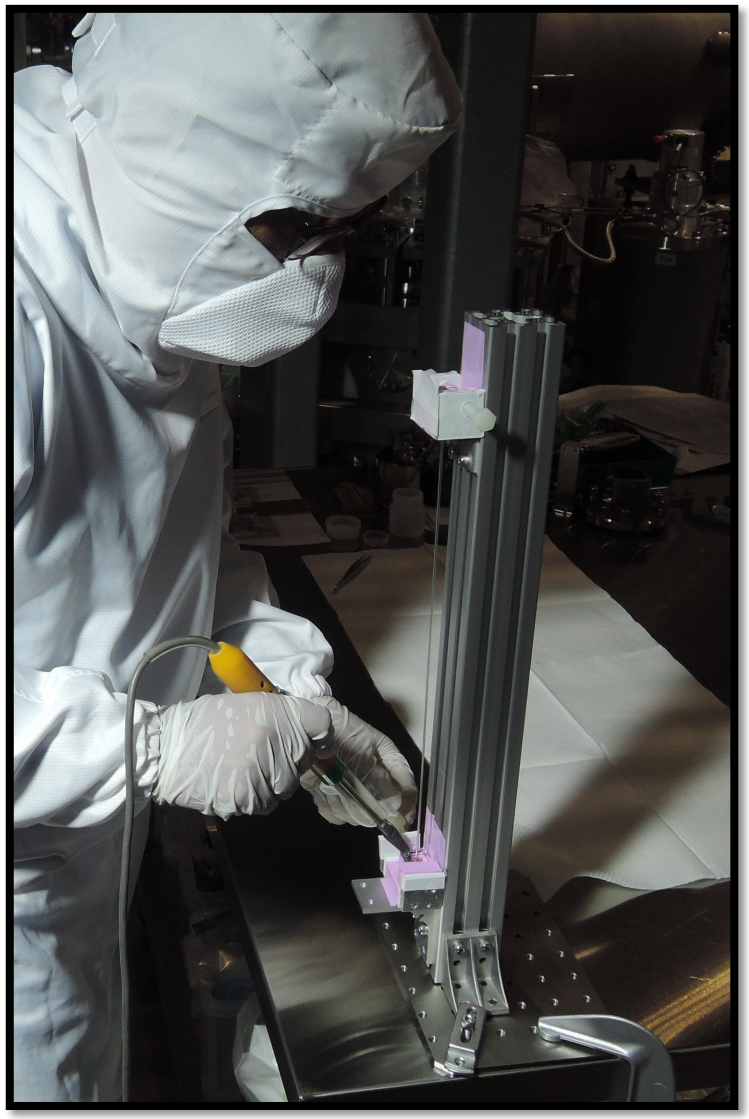
Ga deposition on sapphire fibres

rength tested sapphire fibres are
en selected for use

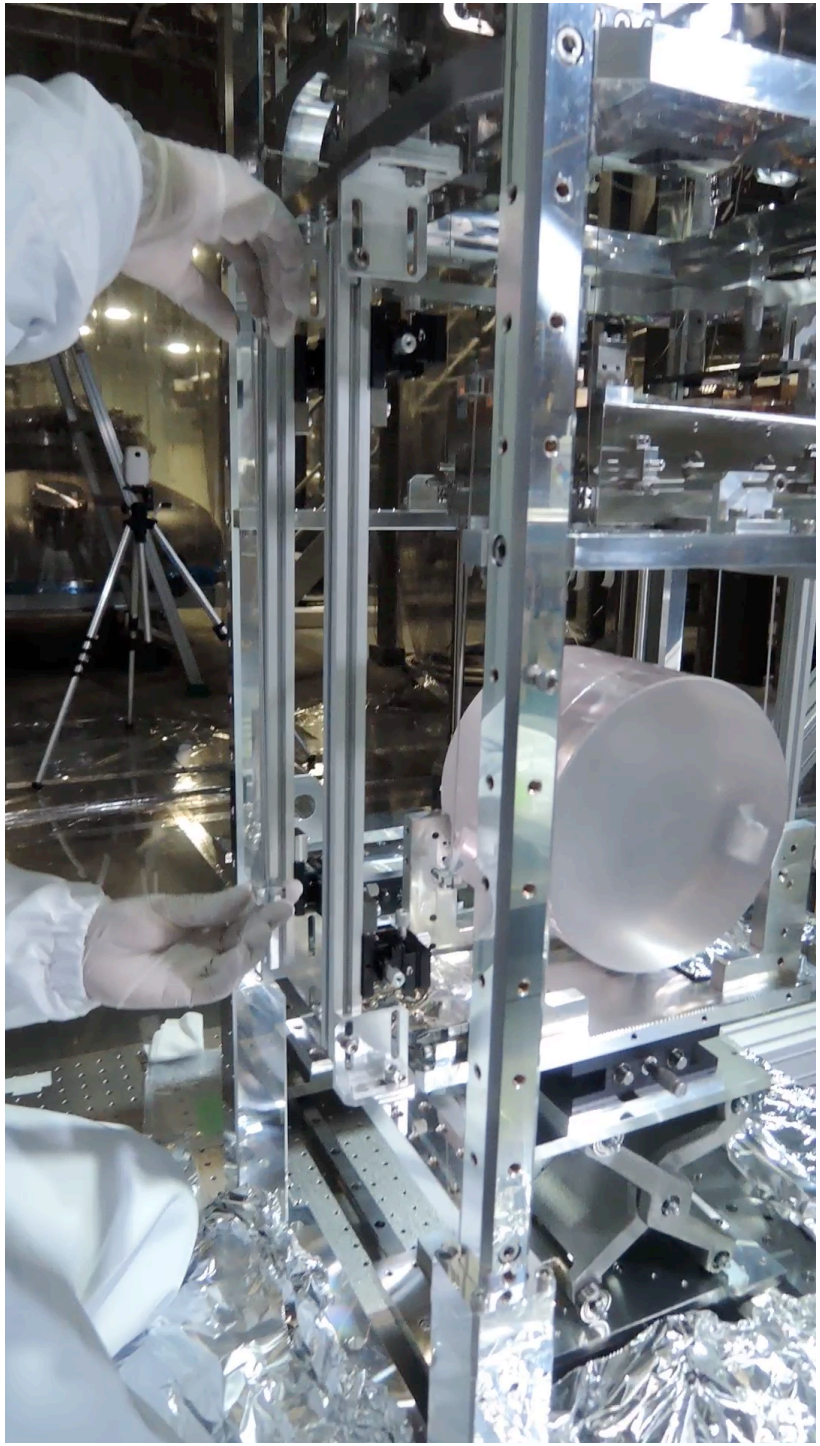
allium is deposited on the top and
ttom surfaces of the sapphire nail
ads

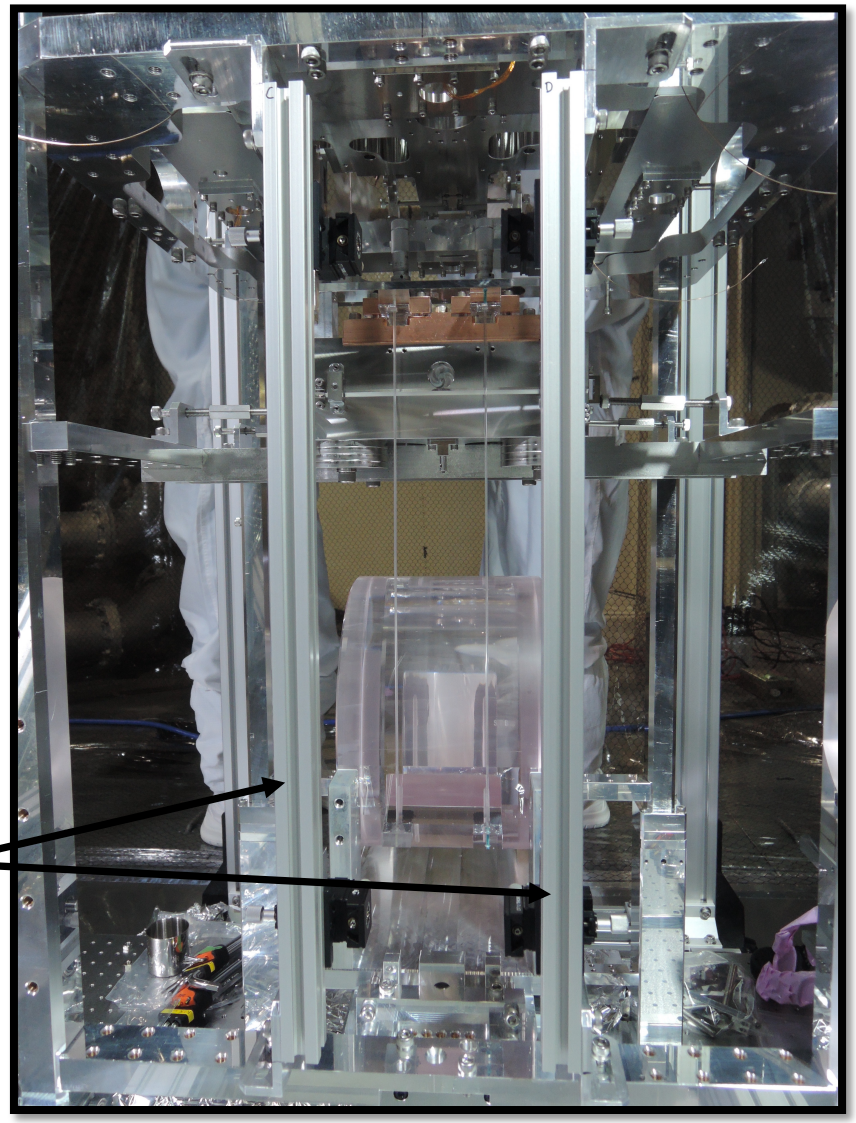
pphire fibres have length
fference ranging from 0.1 mm to
mm

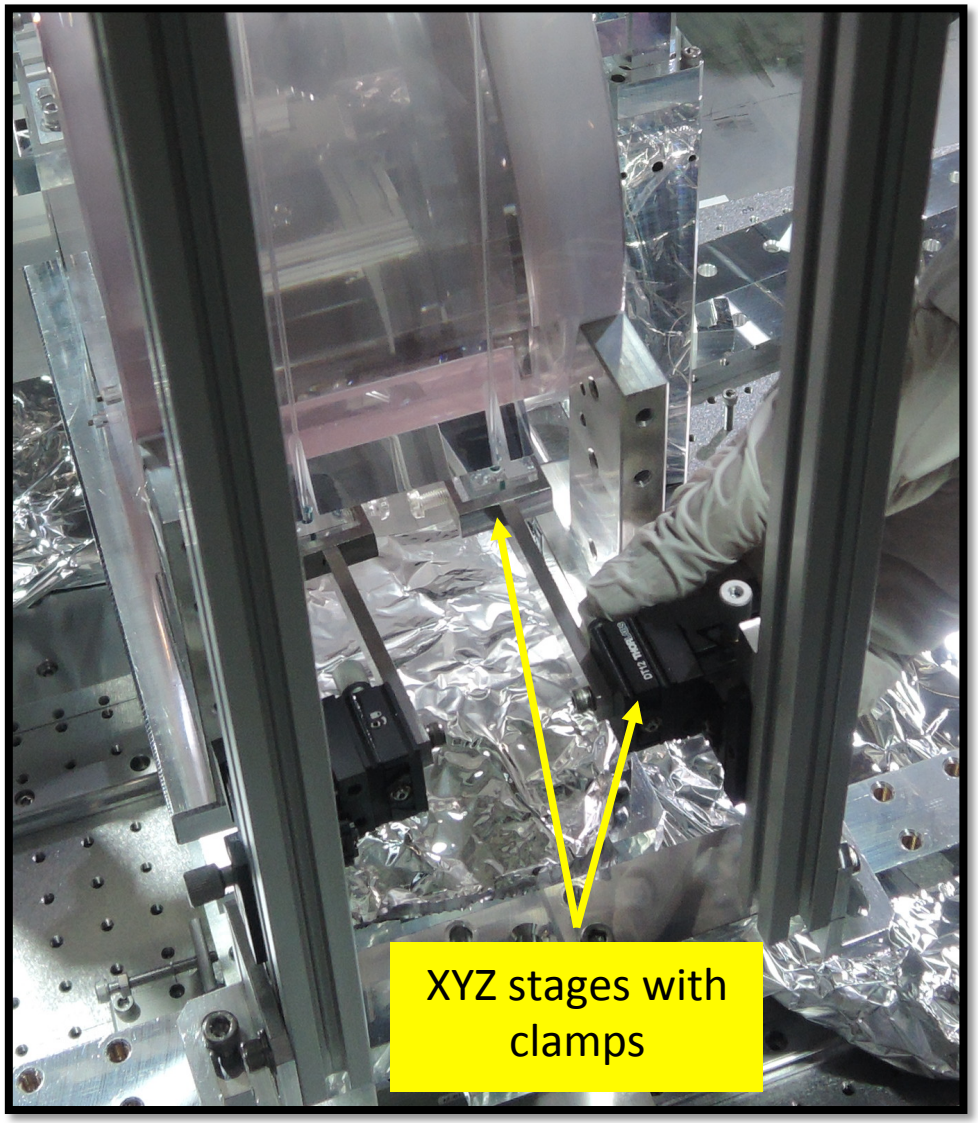
e adjust the clamp (IM) position
ing copper shims to compensate
r the length difference



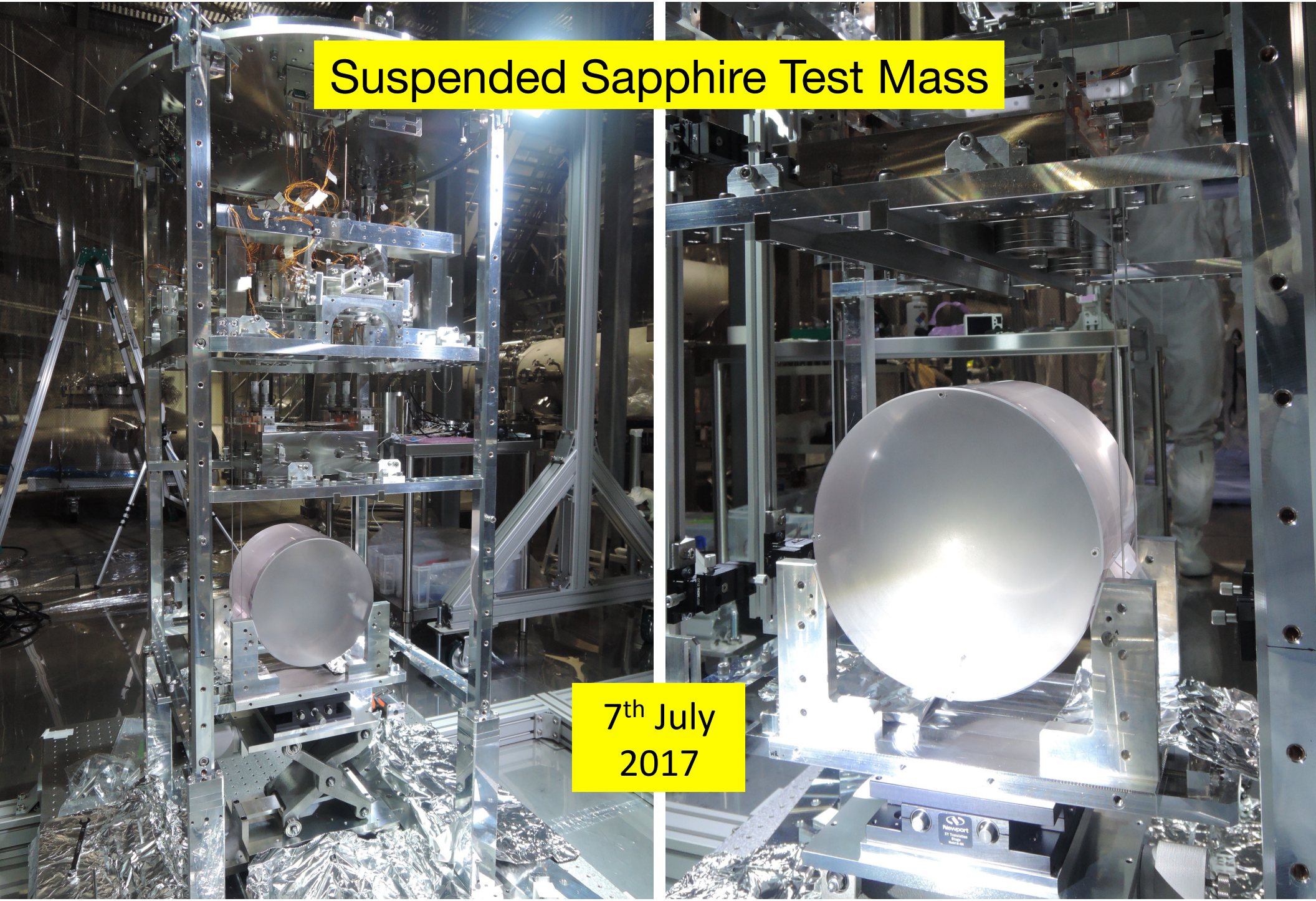
Sapphire fibres are inserted into the suspension

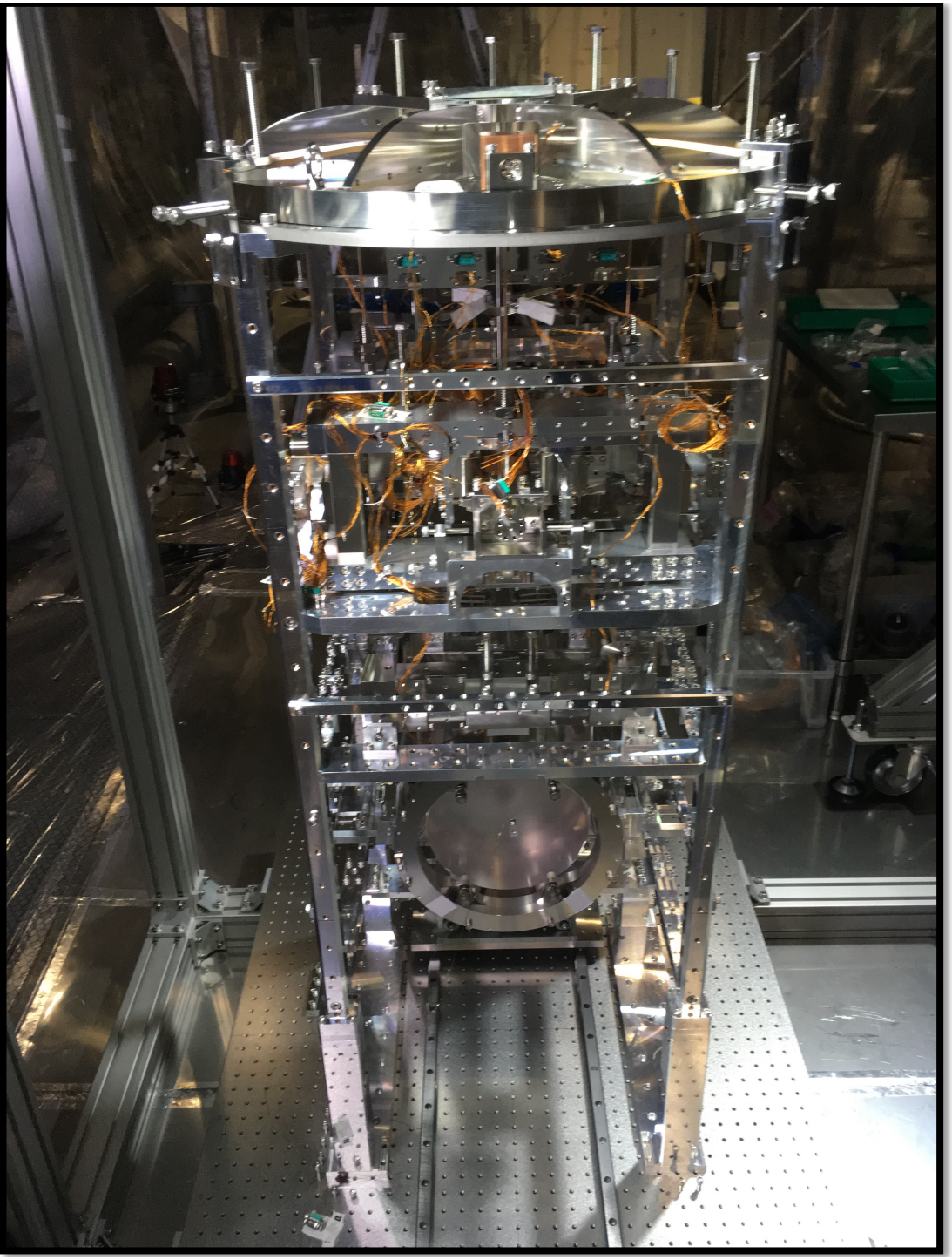




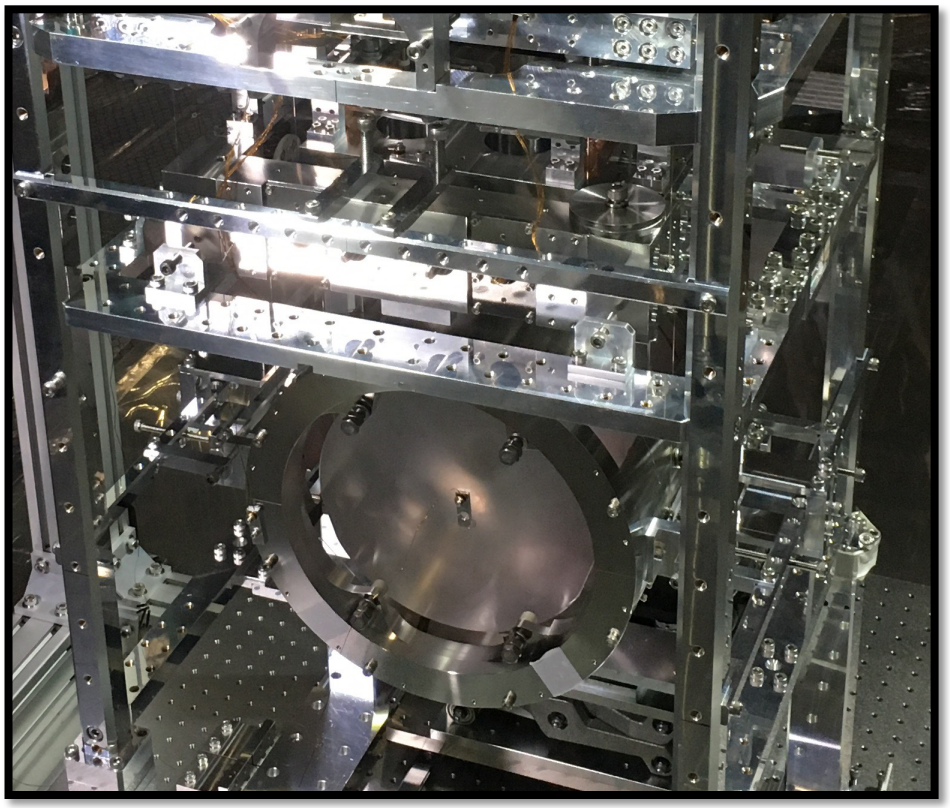


- Fibre holders are also attached to the frame structure
- Sapphire fibres are then positioned using XYZ stages and then clamped
- Welding: using halogen lamp (35 W) we melt the gallium and join all 8 weld points


Suspended Sapphire Test Mass
7th July
2017



Fully suspended
Cryogenic Payload system
with all the recoil masses



Ongoing/future work

Cryogenic suspension system will be moved into the cryostat very soon

CRYO+VIS chain will be connected

Vacuum pumping and cool down test will begin thereafter

We will perform a heat load test on the sapphire suspensions

Assembly procedure will be fine tuned before the final assembly for bKAGRA

Final assembly for the bKAGRA phase 1 will begin from Oct 2017

Conclusions

GRA detector is currently under construction in Japan, located 200 m
lerground and will be operational at 20 Kelvin

AGRA phase 1 will have simple Michelson interferometer set-up

ogenic payload system has 4 stages and the final stage comprises of sapphir
pensions with 23 kg sapphire mirror

1st prototype sapphire suspension system was successfully assembled at KI
y 2017

all metal cryogenic payload system was assembled at the KAGRA site

nplete cryo-pendulum including sapphire suspension system was successful
pended at KAGRA site

lium was used a weld material for jointing sapphire components

eral tests on the cryogenic payload/sapphire suspensions are currently ongo

aim to finish the assembly of the ETM – X&Y arm by Jan 2018

AGRA phase 1 will begin operation from March 2018