

Assembly of Prototype Sapphire Suspension

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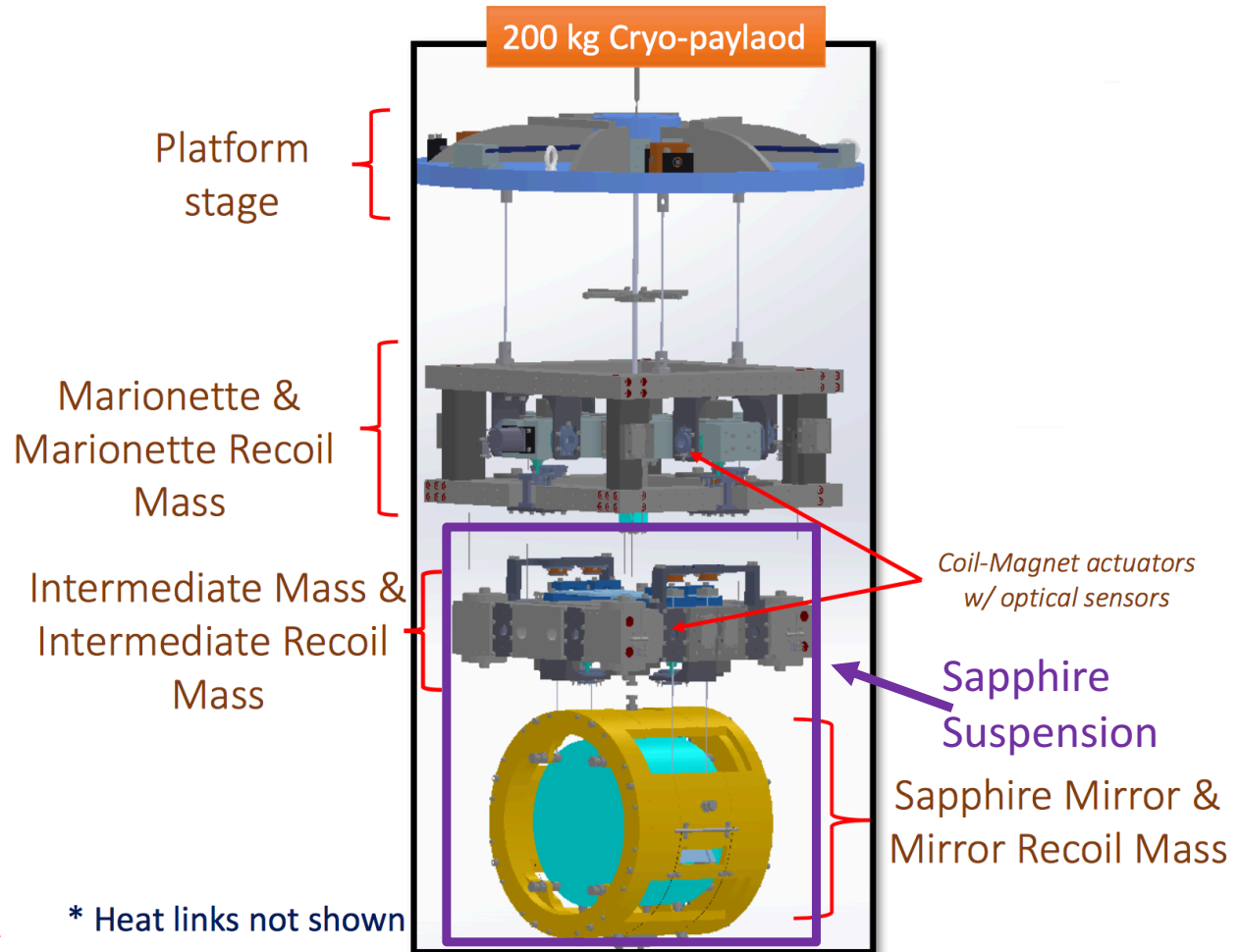
The University of Perugia, Italy⁴

Outline

- Design of Sapphire Suspension System
- Assembly of Sapphire Suspension
- Sapphire Fiber Strength Test
- Future Work
- Summary

Cryogenic Payload System

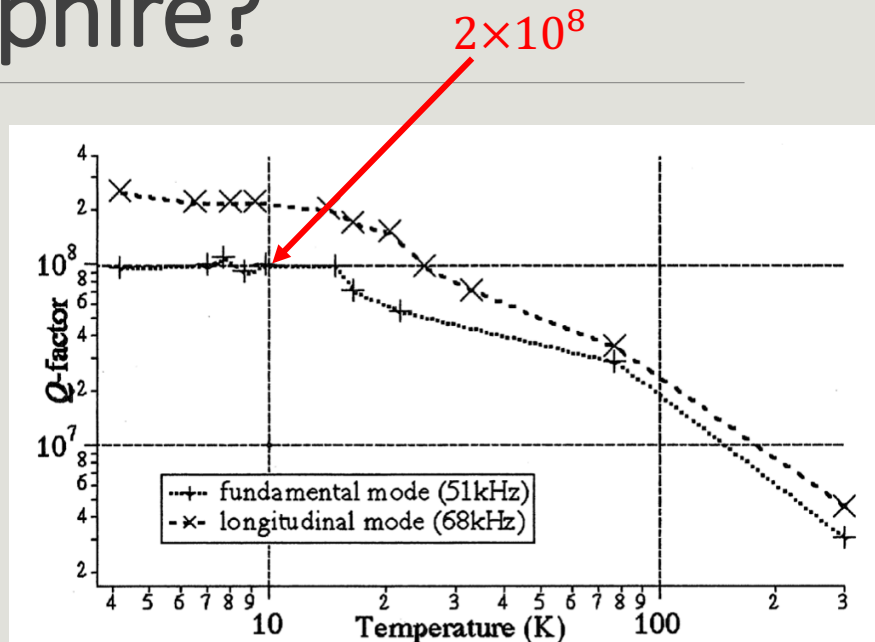
Operational temperature - 20 K



Why do we use Sapphire?

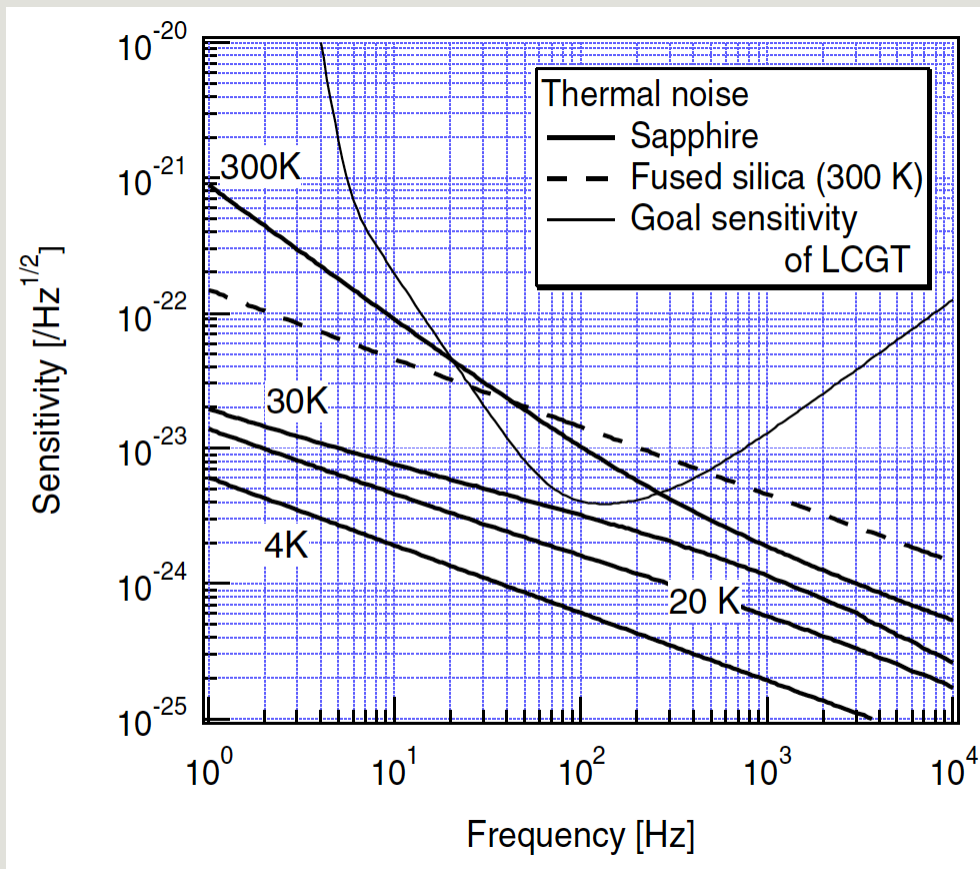
- To reduce the thermal noise fluctuations and increase the sensitivity of the detector
- Thermal noise power spectrum

$$\langle x^2 \rangle \propto T \times \phi = \frac{T}{Q}$$



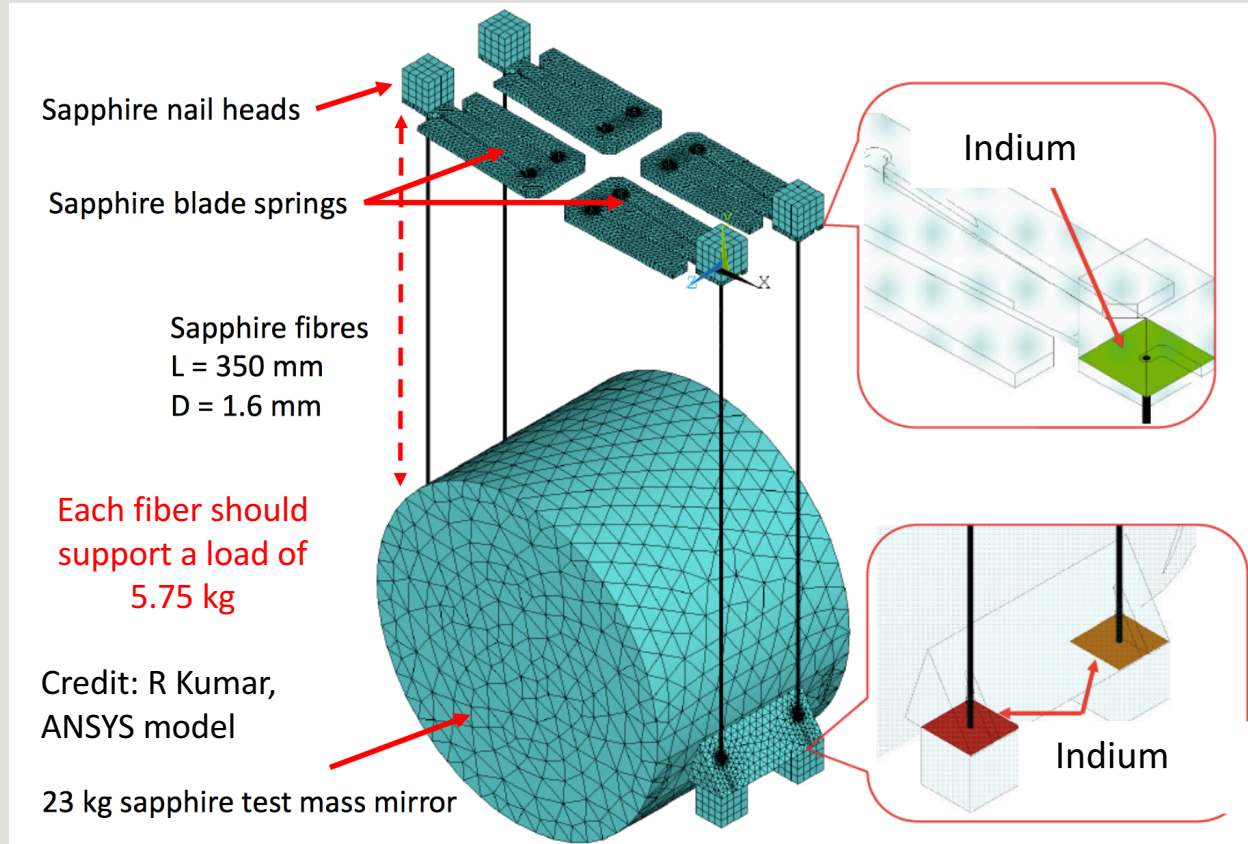
T. Uchiyama et al., Physics Letters A 261(1999)5

Thermal Noise



K. Yamamoto et al.,
PHYSICAL REVIEW D 74,
022002 (2006)

Sapphire Suspension



Assembly of Prototype Sapphire Suspension

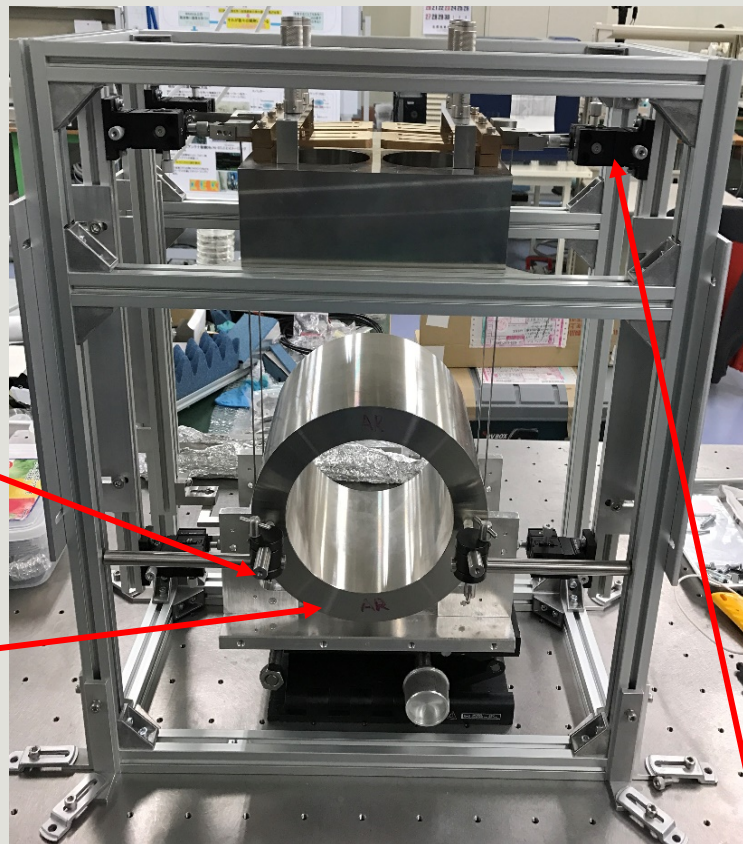
1. Assembled of all metal prototype(22 kg dummy mirror, CuBe blade springs and metal fibers)
2. Replaced metal dummy mirror with sapphire mirror
3. Replaced CuBe blade spring with sapphire blade spring
4. Replaced metal fibers with sapphire fibers and suspend the sapphire mirror

Characterization (Sapphire Suspension)

1. Check the strength of the suspended system
2. Measure the resonant frequency of sapphire suspension system
3. Perform a cool down test in cryostat at KEK

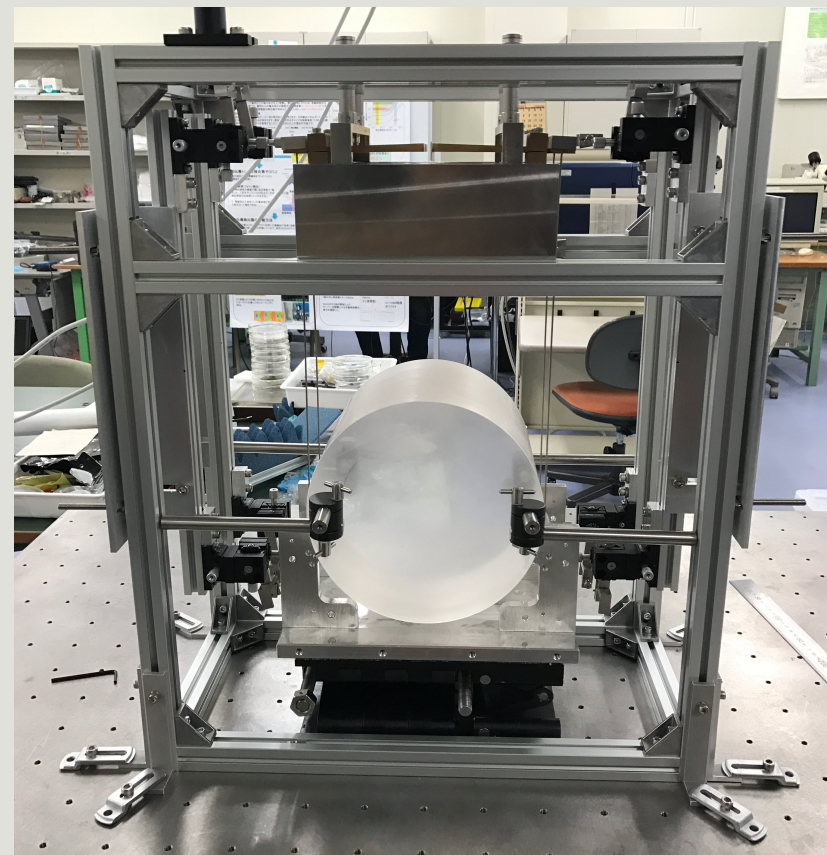
Earthquake
stopper

22kg dummy
mirror

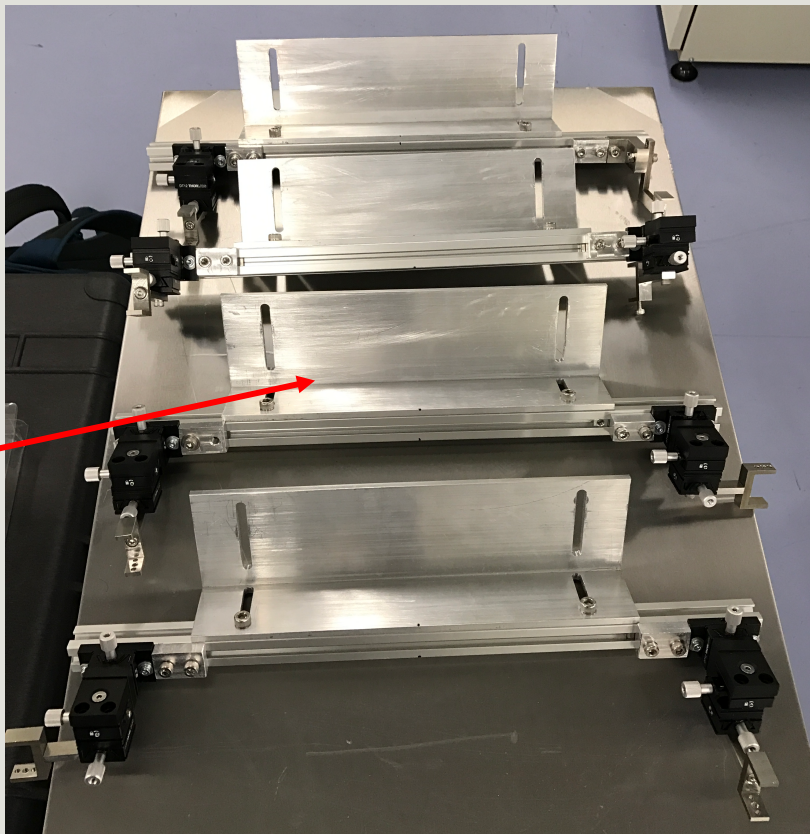


All metal prototype

Fiber holder



Replace with sapphire mirror



Brackets for attachment at support structure



Nail head clamps

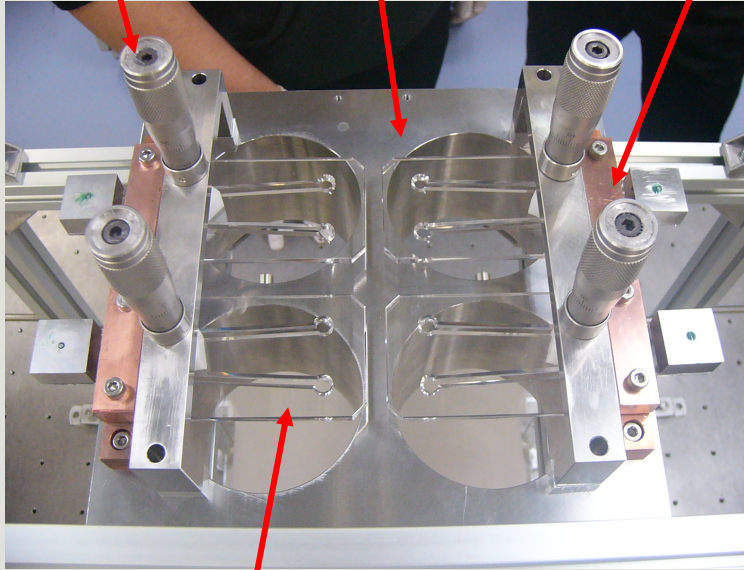
3 axis linear stages

Sapphire fiber holders

Intermediate mass

Micrometer screw

Copper clamp



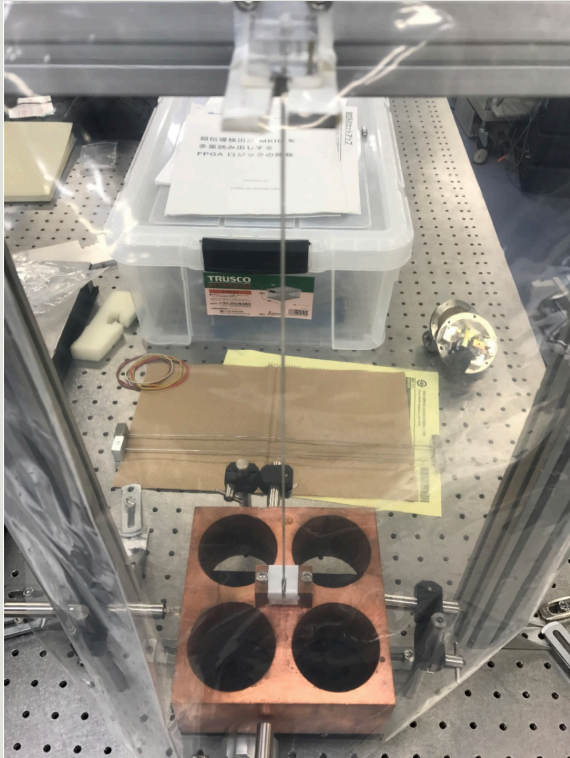
Sapphire blade springs



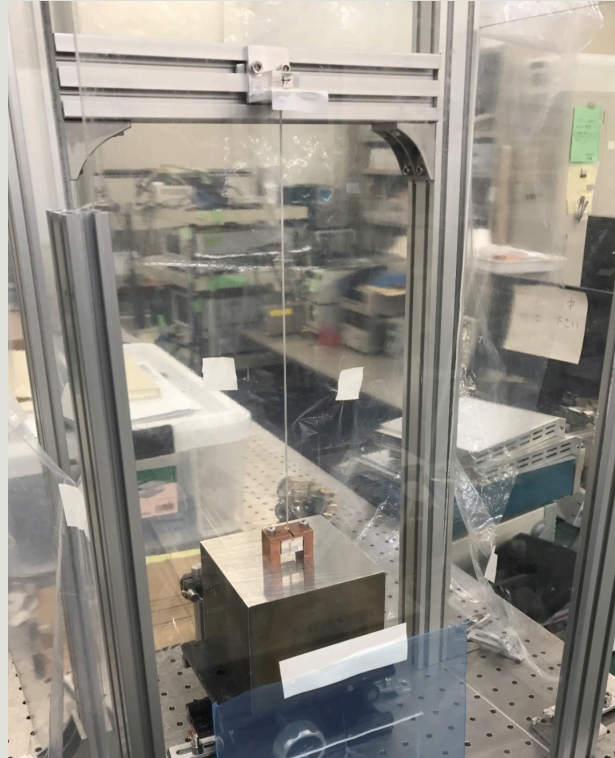
Sapphire fiber



Fiber Strength Test



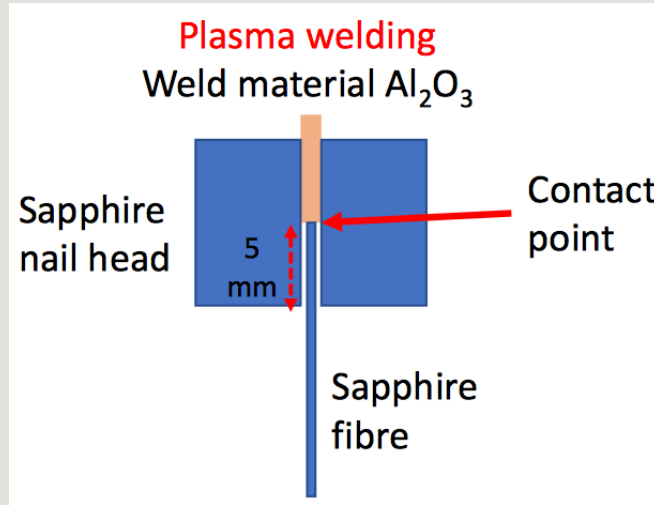
Load 6 kg



Load 12 kg

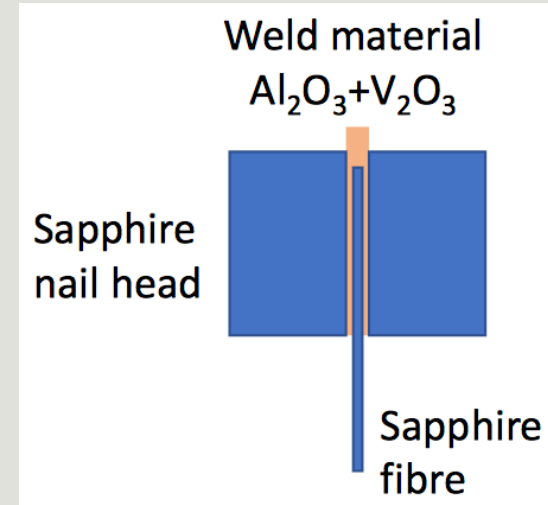
- Proof check – Sapphire fibers should survive 6 kg & 12 kg load test for 1 hour each (safety factor 2)
- We strength tested 22 sapphire fibers from IMPEX
- 12 sapphire were found to be strong
- 10 fibers were found to be weak at weld points

Why Sapphire Fiber broke?



2014 fibers construction schematic

Only 1 of the 6 fibers in 2014 batch survived 6kg load (i.e. 5 were broken)

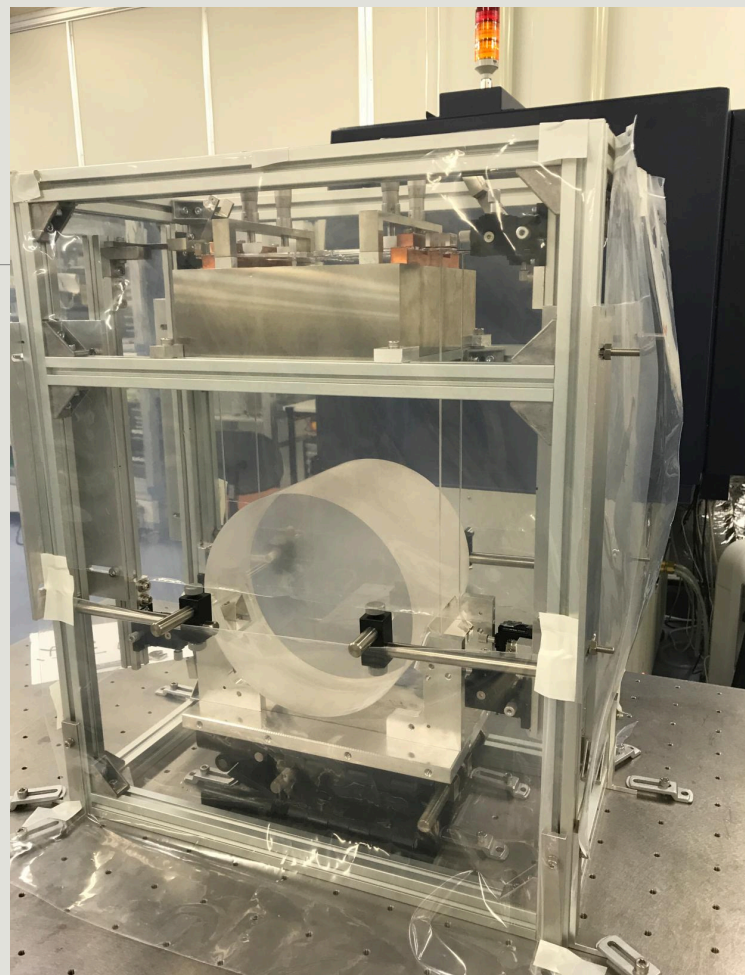


2015-16 fibers construction schematic

Finally **12 sapphire fibers out of 16** survived 12 kg load test (1 hour of hanging)

Successful test hang of Sapphire Suspension

On May 13th 2017, we
suspended 22kg sapphire test
mass on 4 sapphire fibers and 4
sapphire blade springs



Future Work

1. Measure the resonant frequency of sapphire suspension system
2. Perform a cool down test in cryostat

Summary

- We performed test hanging using metal blade springs and fibers, then replaced metal components with sapphire in a step by step process.
- We tested the sapphire fibers strength using 6kg and 12 kg mass. 12 fibers survived the strength test.
- We successfully assembled and suspended the prototype sapphire suspension system.

The End
Thanks for your listen