Q measurements of sapphire samples for KAGRA suspension

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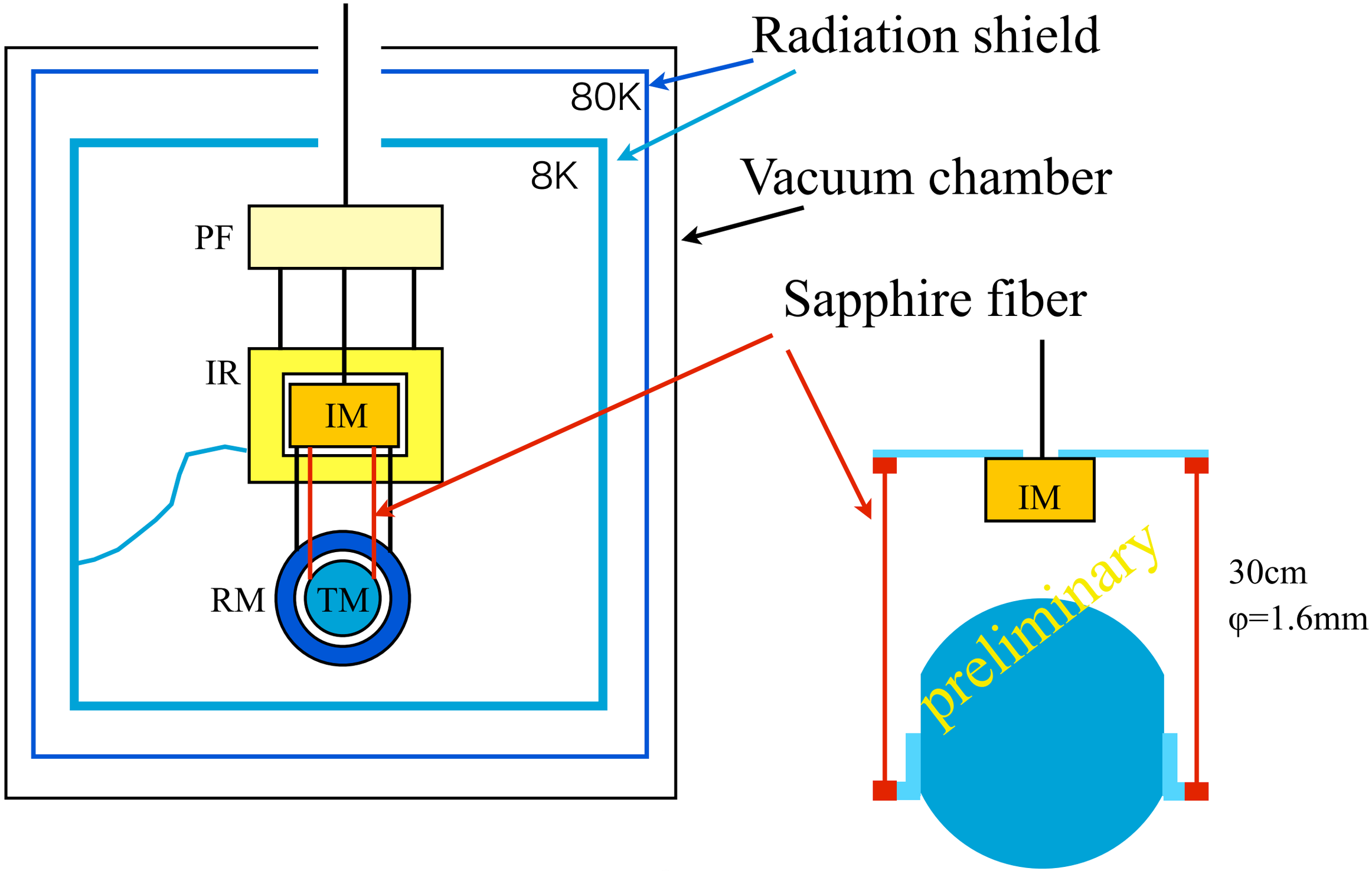
Q measurements of sapphire samples for KAGRA suspension
- Outline -

- Purpose of Q measurement
- Measurement setup
- Result

Where do we use the sapphire fibers?



Purpose

Measurement of sapphire Q for KAGRA mirror suspension

We will use **sapphire fibers** (ϕ 1.6 mm) to suspend cooled sapphire mirrors(20K).

High thermal conductivity → lower cooling time, keep 20K

High Q value → lower thermal noise

Requirments

Thermal conductivity: 5000 W/m/K

Q value: 5×10^6 etc...

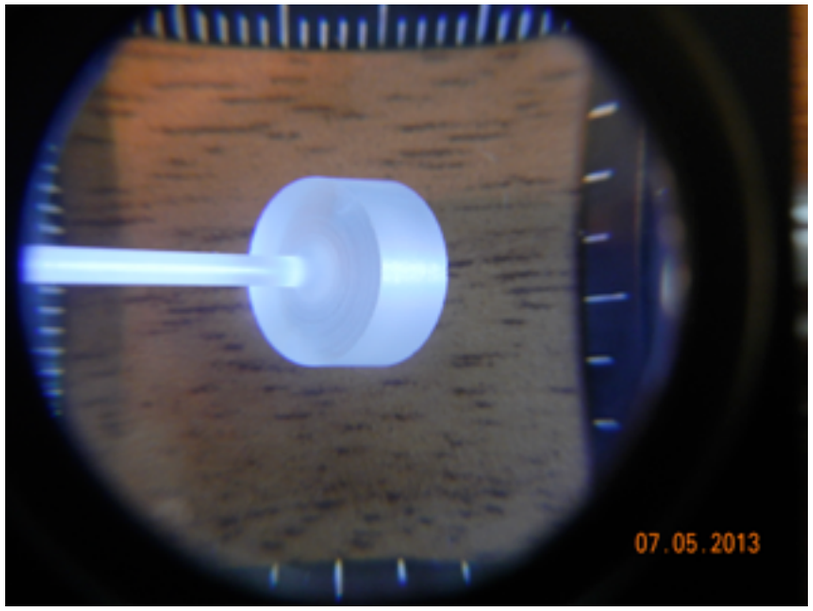
In Rome we tested two samples with good thermal conductivity.

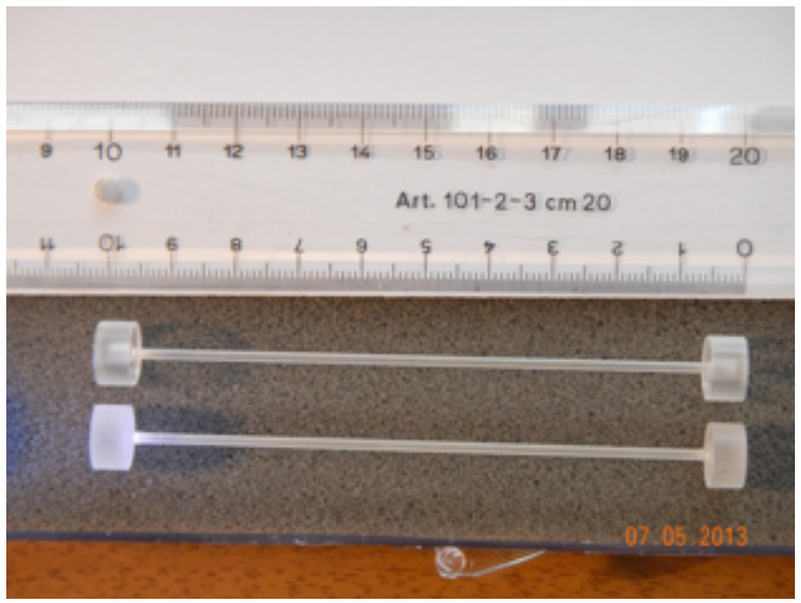
Fiber 1: 5900 W/m/K @20K

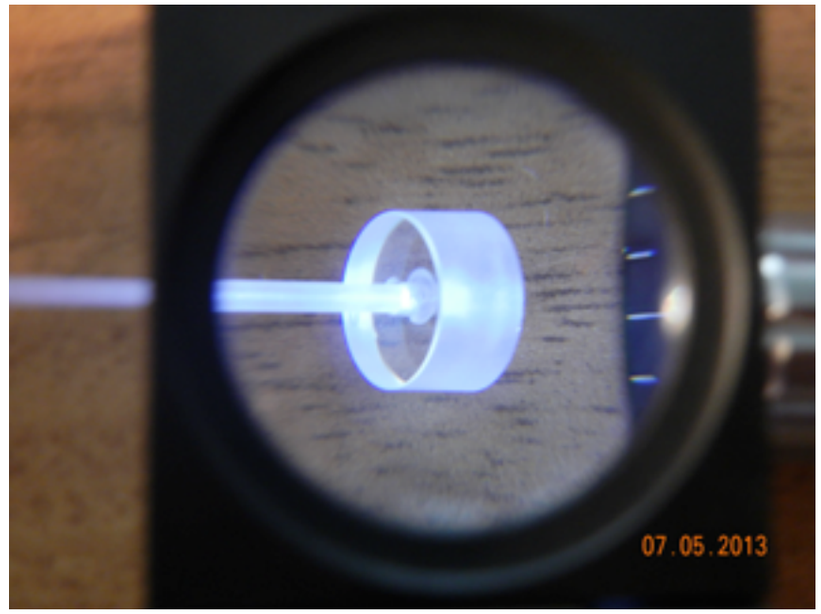
Fiber 2: 6600 W/m/K @20K

→ Our purpose is measuring the Q value of these fibers @ 20K

Sapphire fibers at Rome







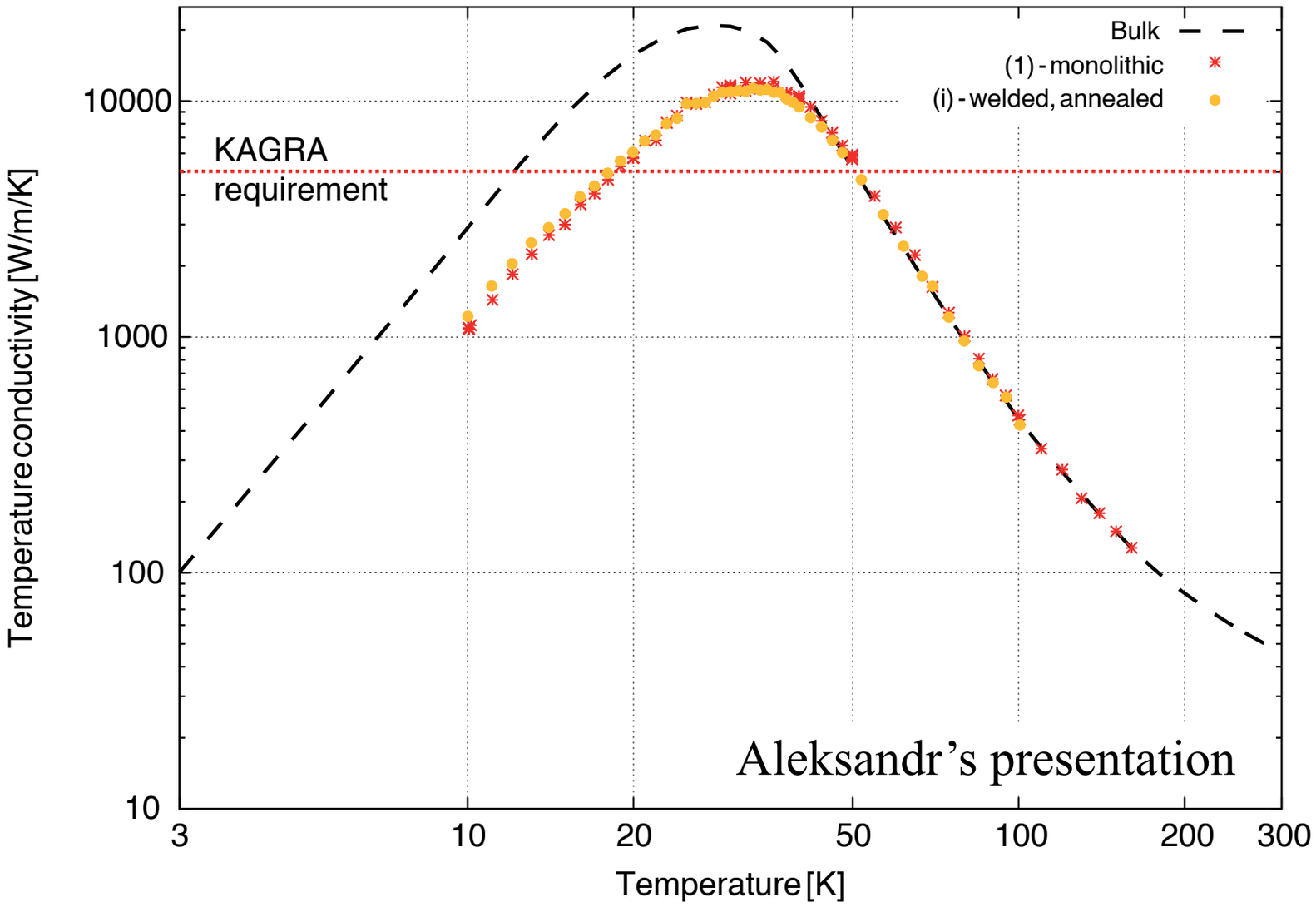
Fiber 1:

- 5500-5900 W/m/K @20K
- Monolithic

Fiber 2:

- 6600 W/m/K @20K
- Non-monolithic
- Brazed through alumina
- HEM
- Thermopolish

Thermal conductivity (fiber part)



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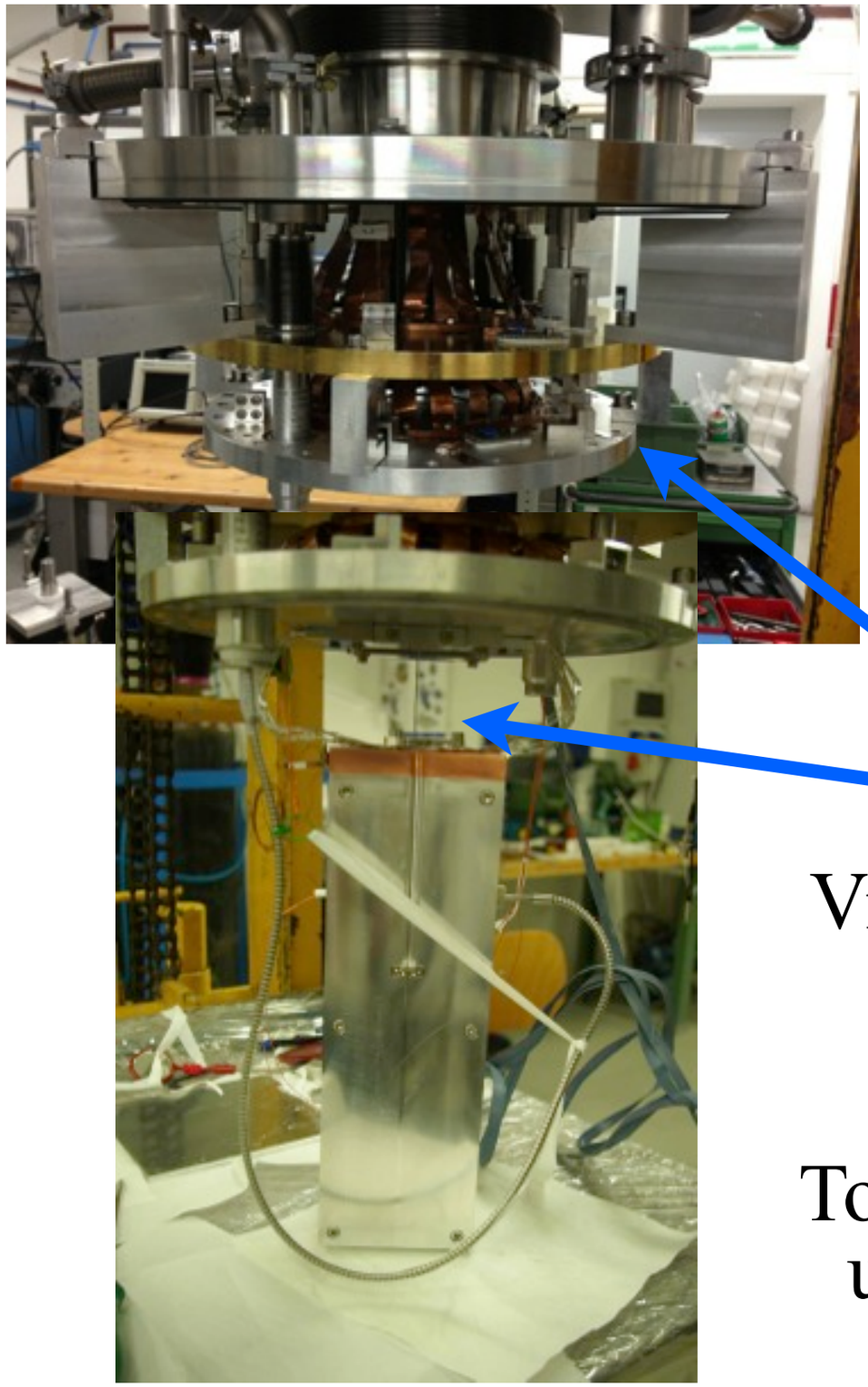
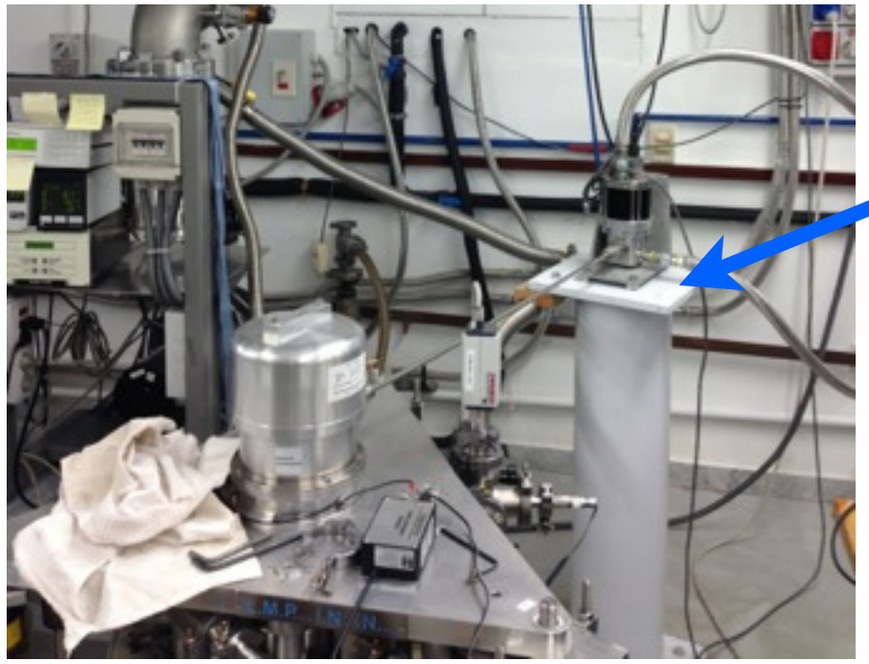
Measurement setup





Fixed on the ground.

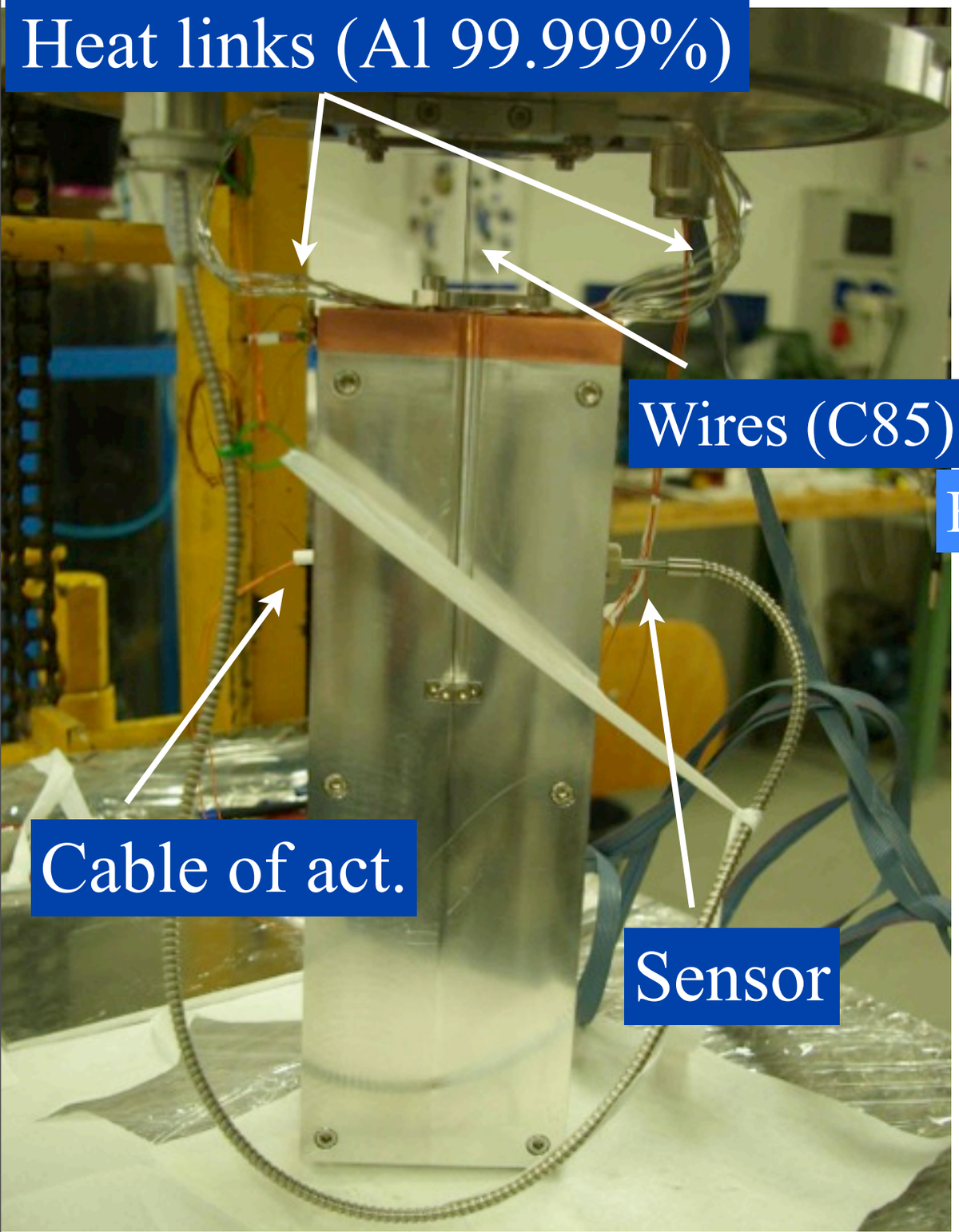
Double pendulum (3 wires)

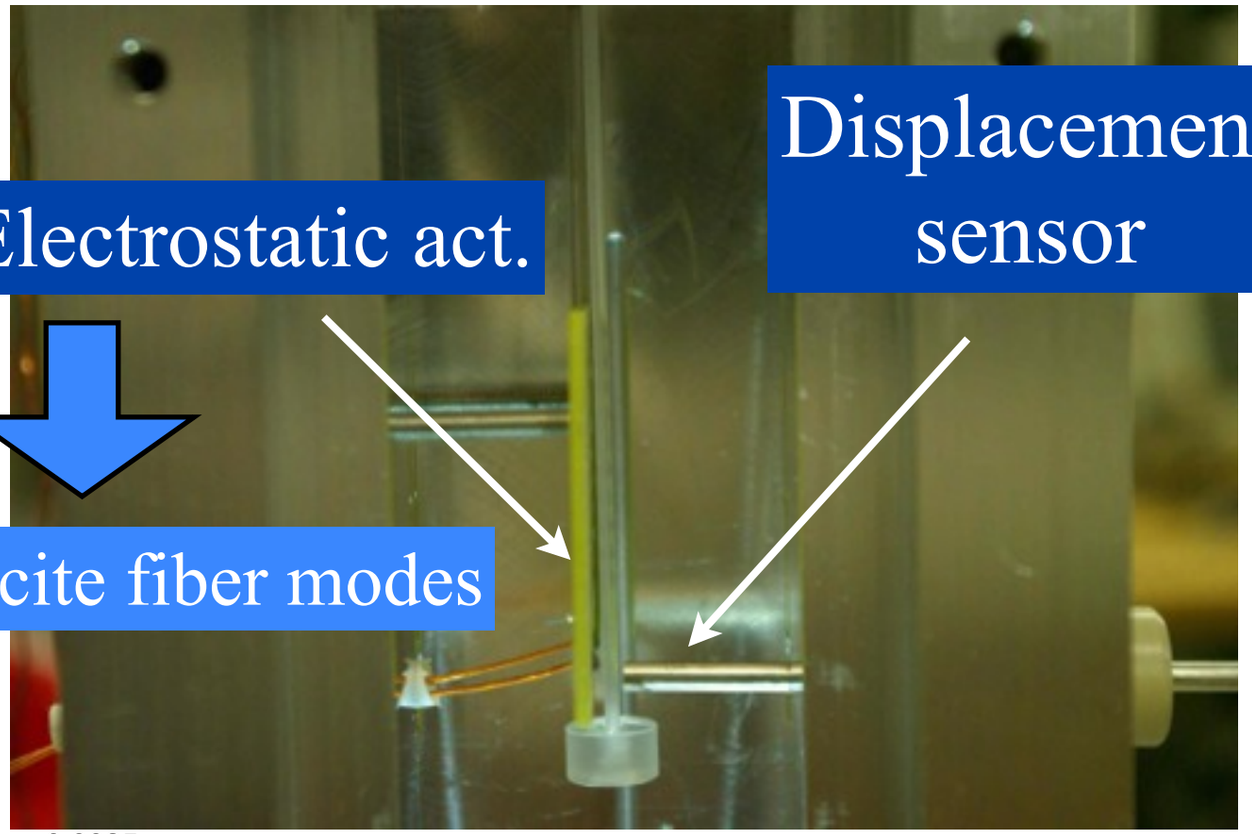
Pendulum (2 wires)

Vibration of pulse tube cryocooler can swing the fiber.

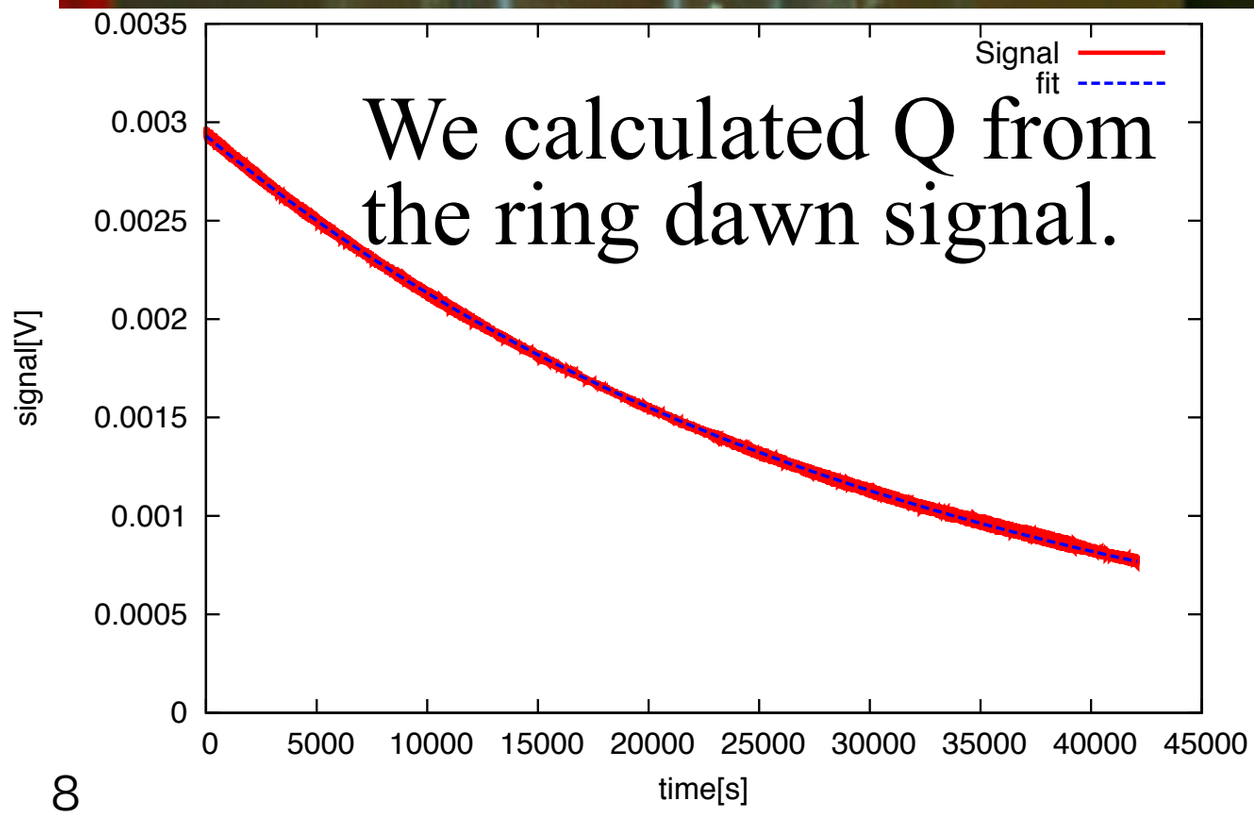
To measure fine vibration of the fiber, we used a low vibration cryoatst at Rome.

Measurement setup

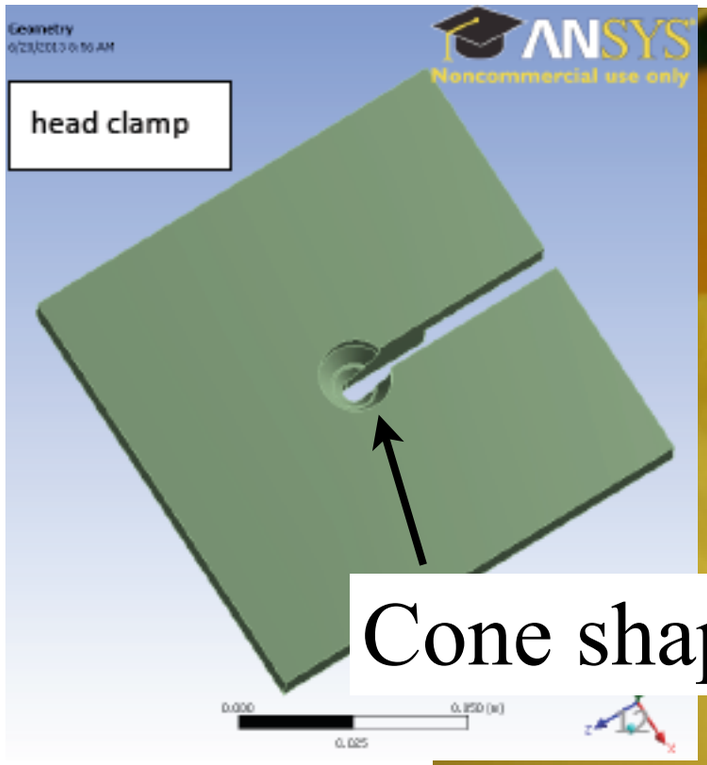


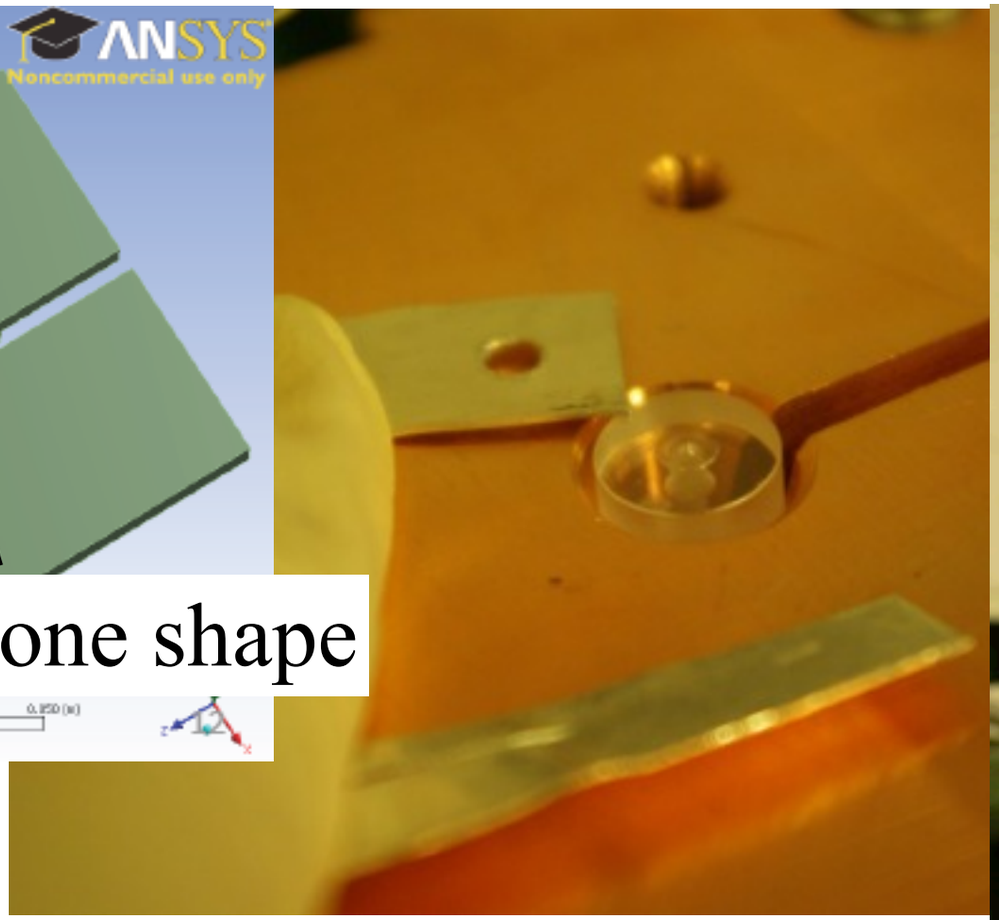


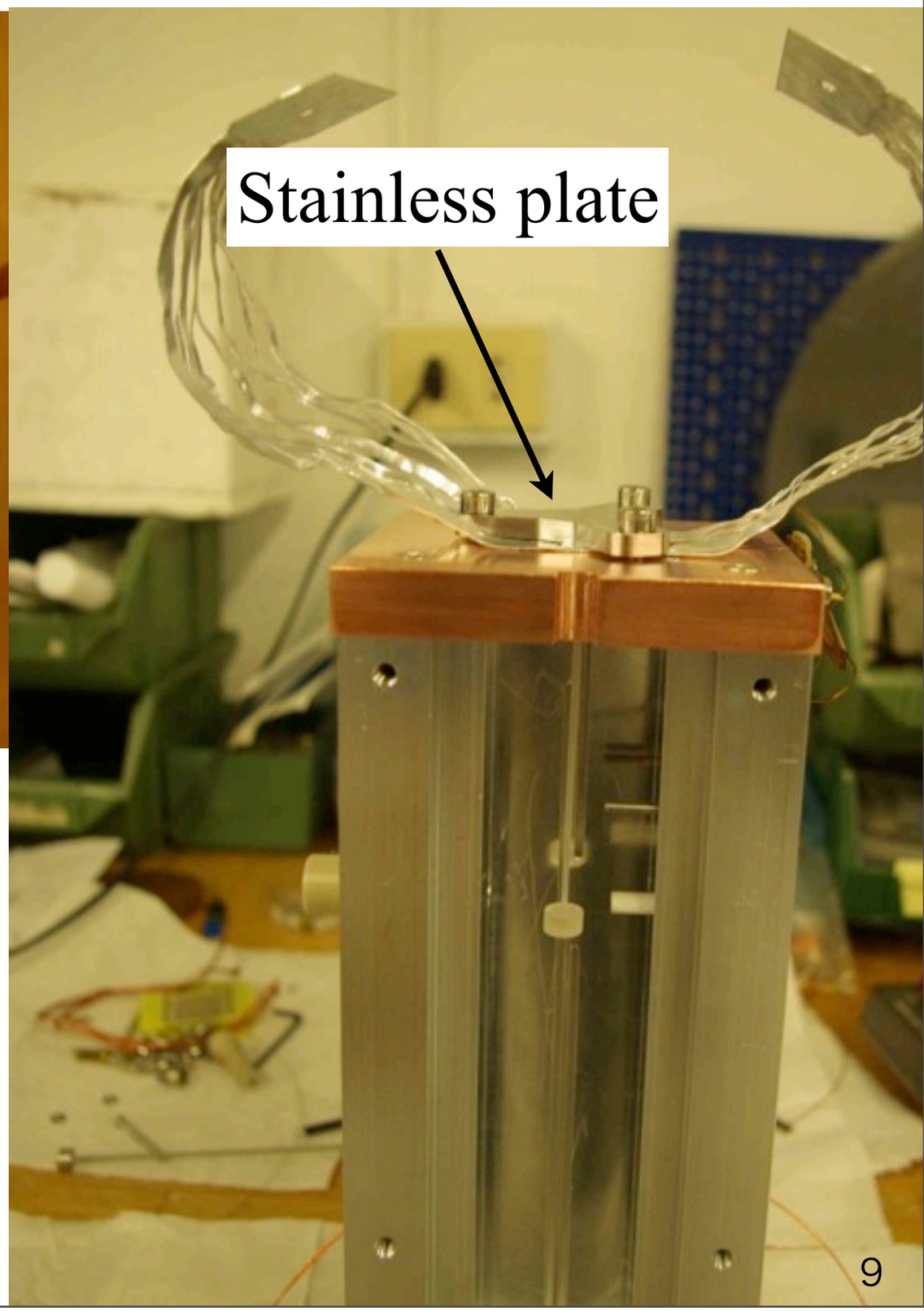
Excite fiber modes



Fix point of the sapphire fiber





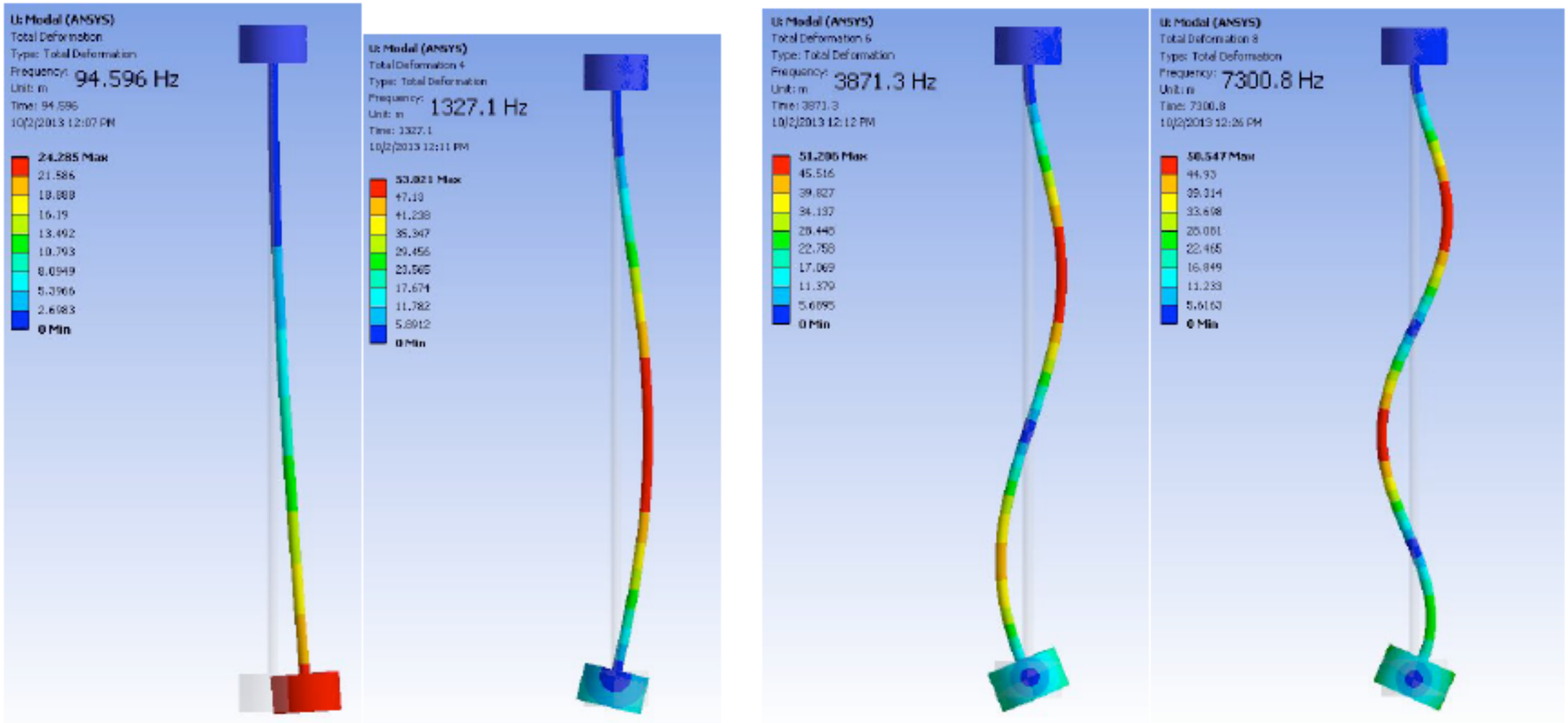


The fiber is fixed with stainless plate and cone shape cupper holder.

To suppress the influence from fix point.

Simulation

Fiber modes

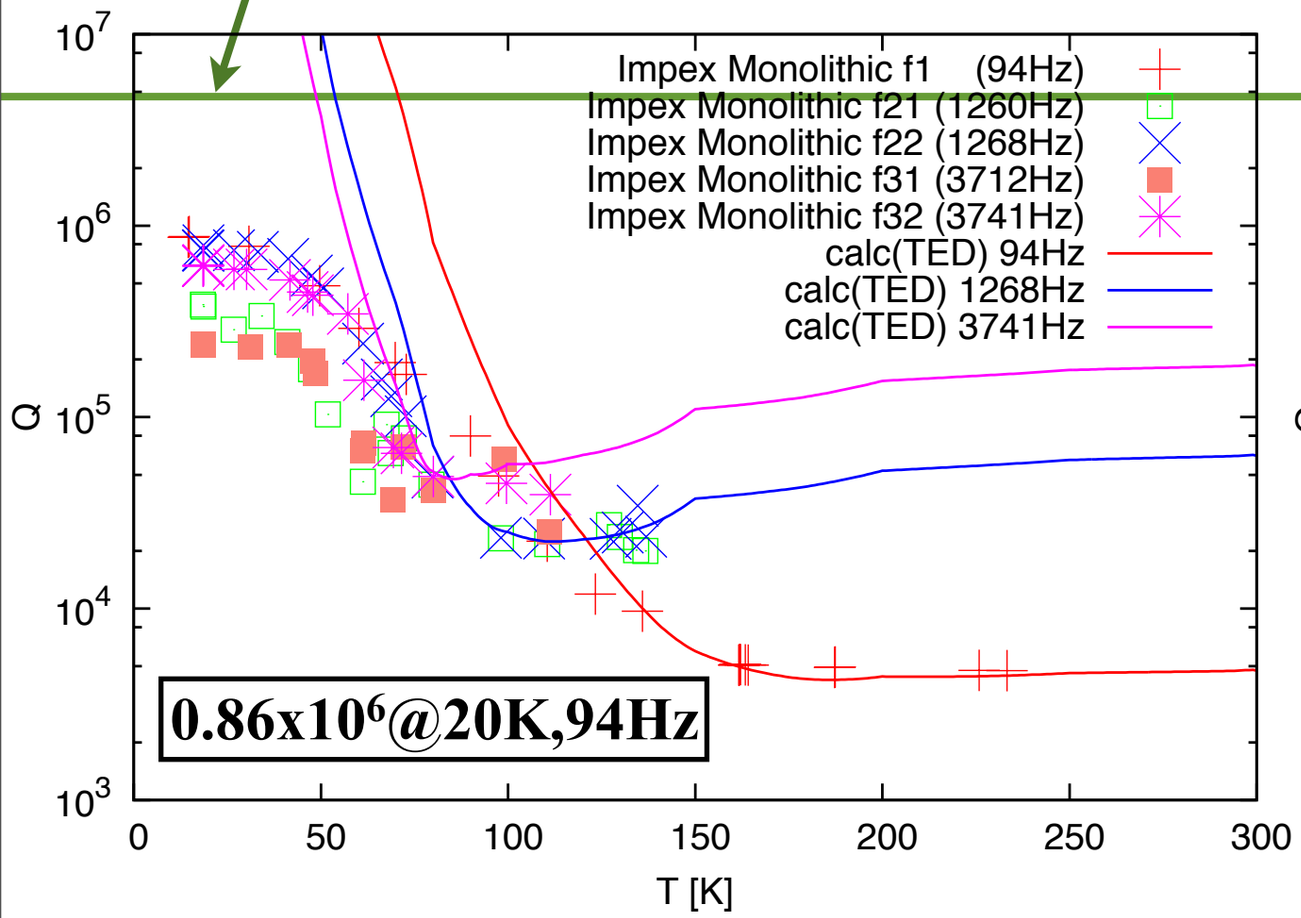


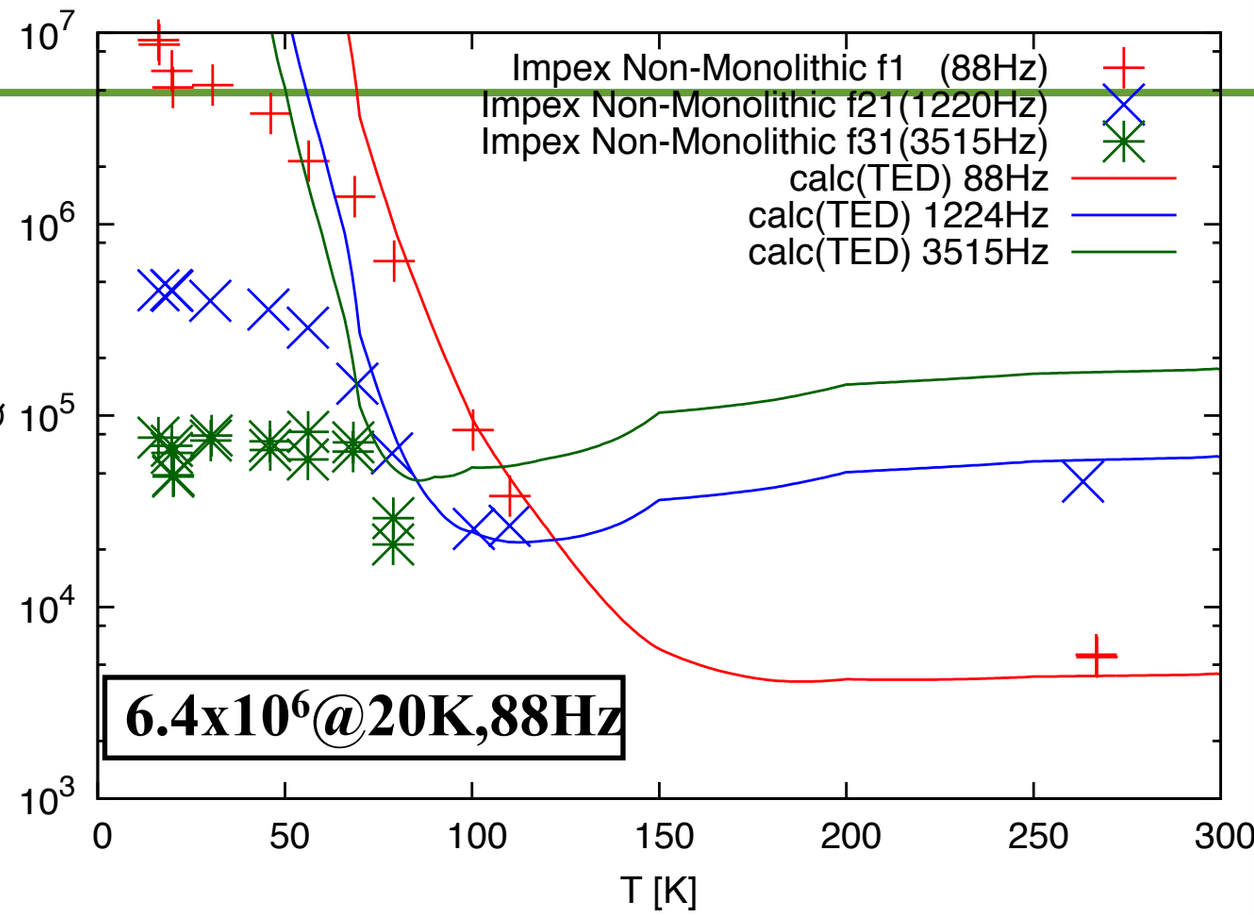
F1 F2 F3 F4

We calculated the resonance frequency of the fiber.
We searched the peaks around these frequency.

Result

Requirement (5x10⁶@20K)



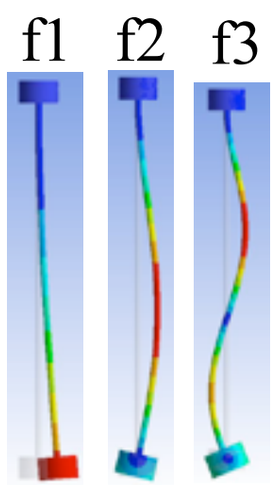


Fiber 1:

- 5900 W/m/K @20K
- Monolithic

Low Q

Modal simulation



Fiber 2:

- 6600 W/m/K @20K
- Non-monolithic
- Brazed throu
- HEM
- Thermopolish

High Q
Higher than requirement

Summary

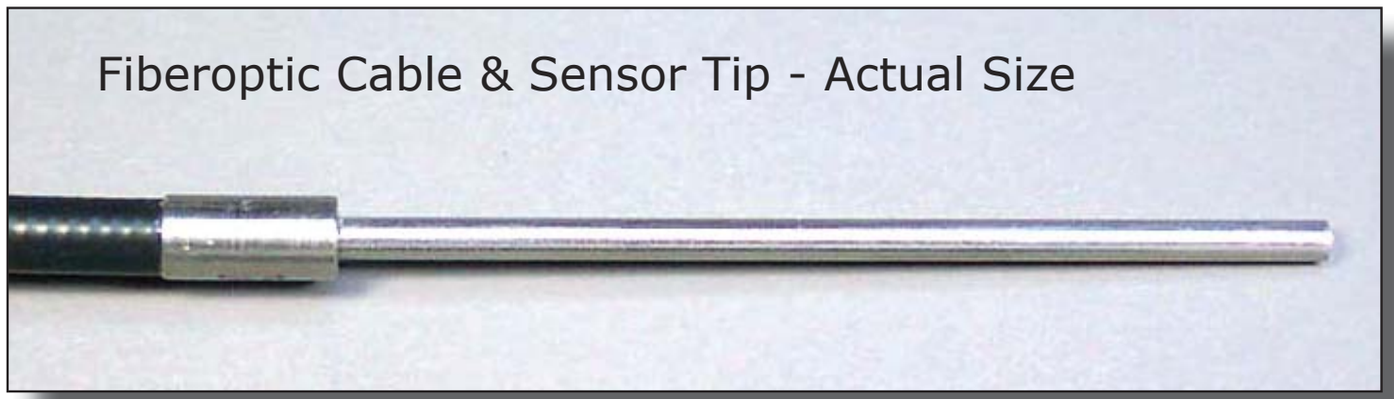
- We measured Q values of two kinds of sapphire fiber whose thermal conductivity is higher than the requirement value.
- One of them has high Q which is higher than requirment value.
- Even non-monolithic fiber can have high Q.
- HEM quality and thermopolishing might improve Q value.

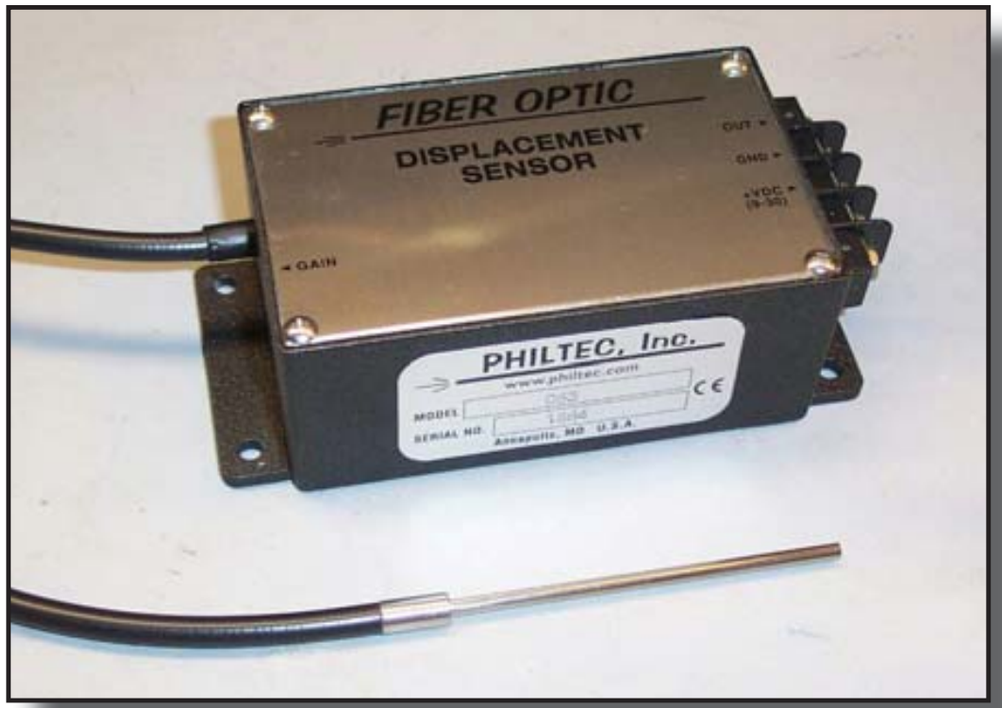
End

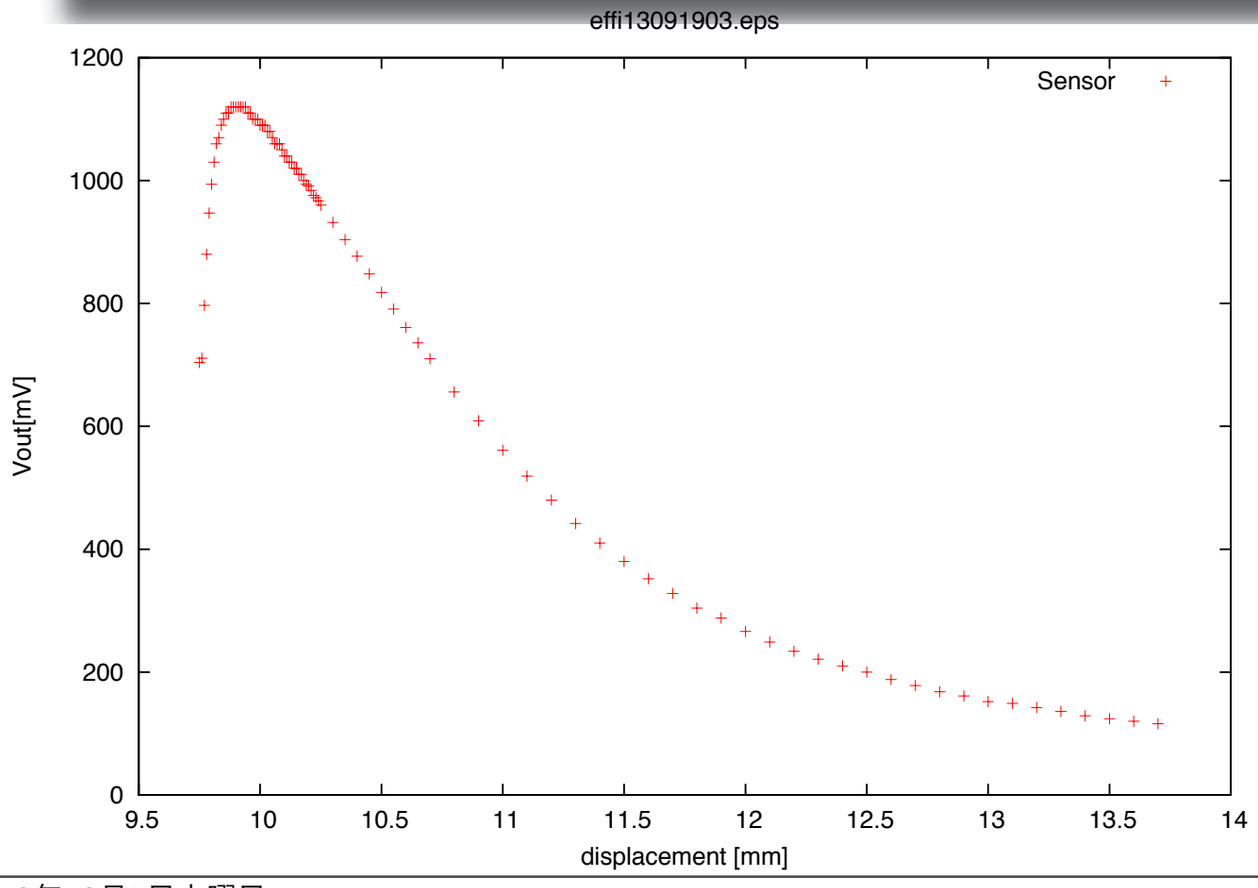
Displacement sensor

Fiberoptic Sensor - *Reflectance Dependent**

Model D63







This is a reflective type transducer based upon detecting the intensity of reflected light.