Vibration measurement of the KAGRA radiation shield

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ICRR The University of Tokyo, KEK[A], the University of Rome[B]

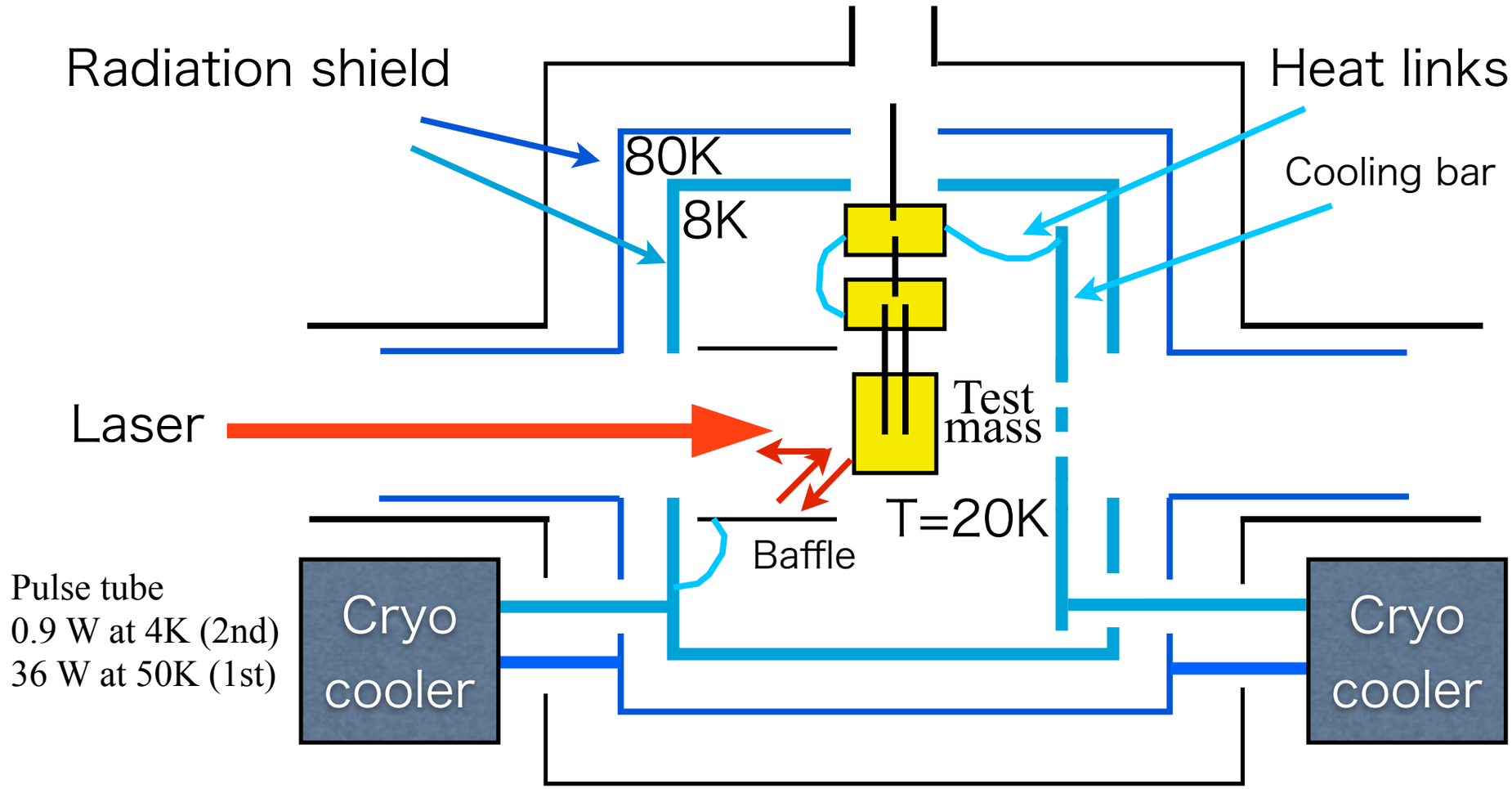
KAGRA f2f meeting 1st Aug. 2013

Outline

- Purpose of the vibration measurement
- Test of the accelerometer
- Measurement of the KAGRA radiation shield
- The impact on the sensitivity of KAGRA

Purpose

Measurement of the vibration of the radiation shield.



Noise of the interferometer ⇐ Vibration from the radiation shield through heat links.
Recoupling into main laser via scattered light

⇒ Vibration measurement of the radiation shield during the cryocooler operation (@Toshiba Keihin Product Operations, Yokohama-city).

⇒ Measure the vibration of the radiation shield, and estimate the influence on the sensitivity of KAGRA.

Requirements for the accelerometer

1.Seismic motion at Yokohama can be measured: 10^{-9}m/rtHz@10Hz

2.Operation at low temperature (down to 10K)

Vertical direction

We used an accelerometer developed in Rome Univ.

→ The data analysis is in progress.

Horizontal direction

We used a Michelson interferometer as an accelerometer.

→ We can use the wavelength to calibrate the accelerometer.

We will mainly report about the horizontal measurement.

Schedule of the vibration measurement

March 2013 (First cooling test of the cryostats)

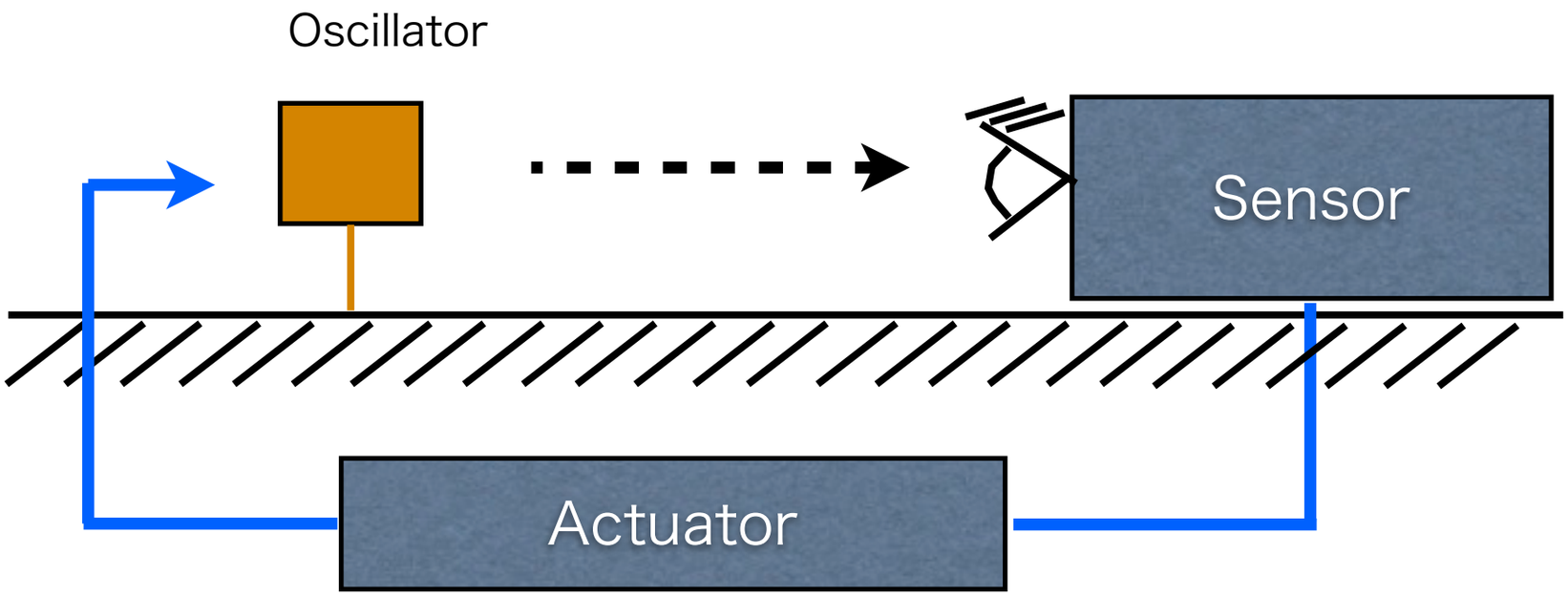
Cryostat	#2	#3
Accelerometer	Vertical	Horizontal

July 2013 (Second cooling test of the cryostat)

Cryostat	#3
Accelerometer	Vertical and Horizontal

Principle

-of the seismic vibration measurement-

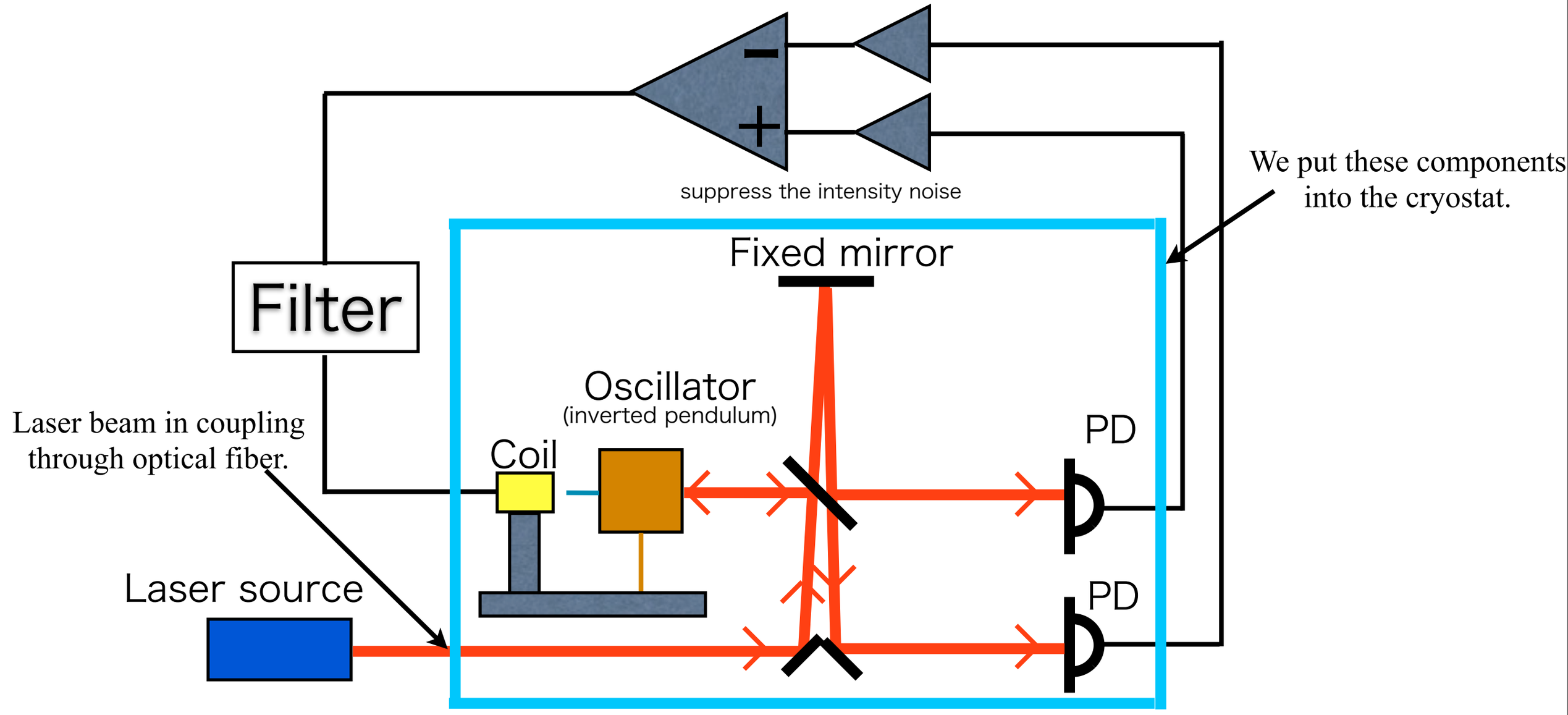


A sensor detects the displacement between the oscillator and the ground.

A feedback signal is generated to restore the oscillator position.

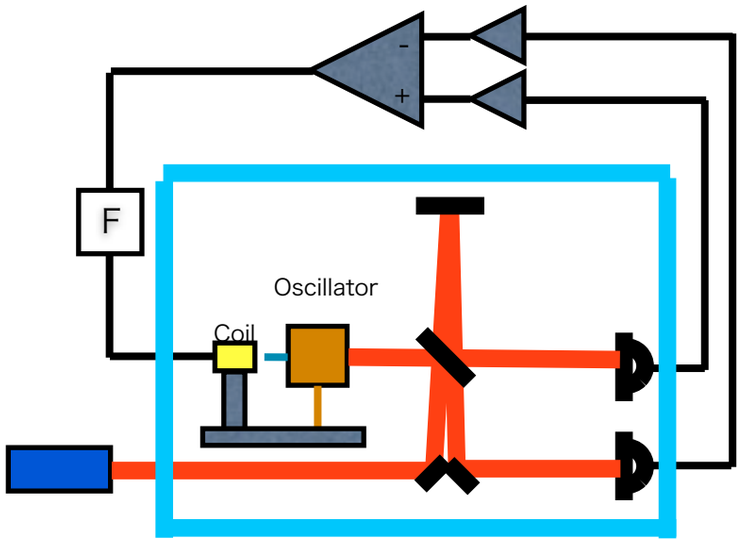
From this signal, the seismic vibration is derived.

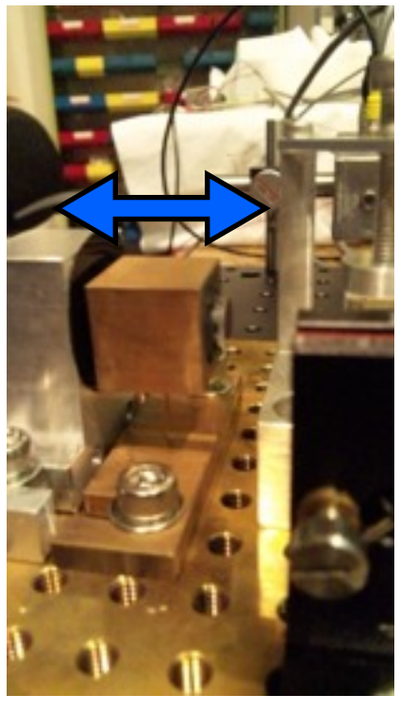
Concept of the ICRR accelerometer



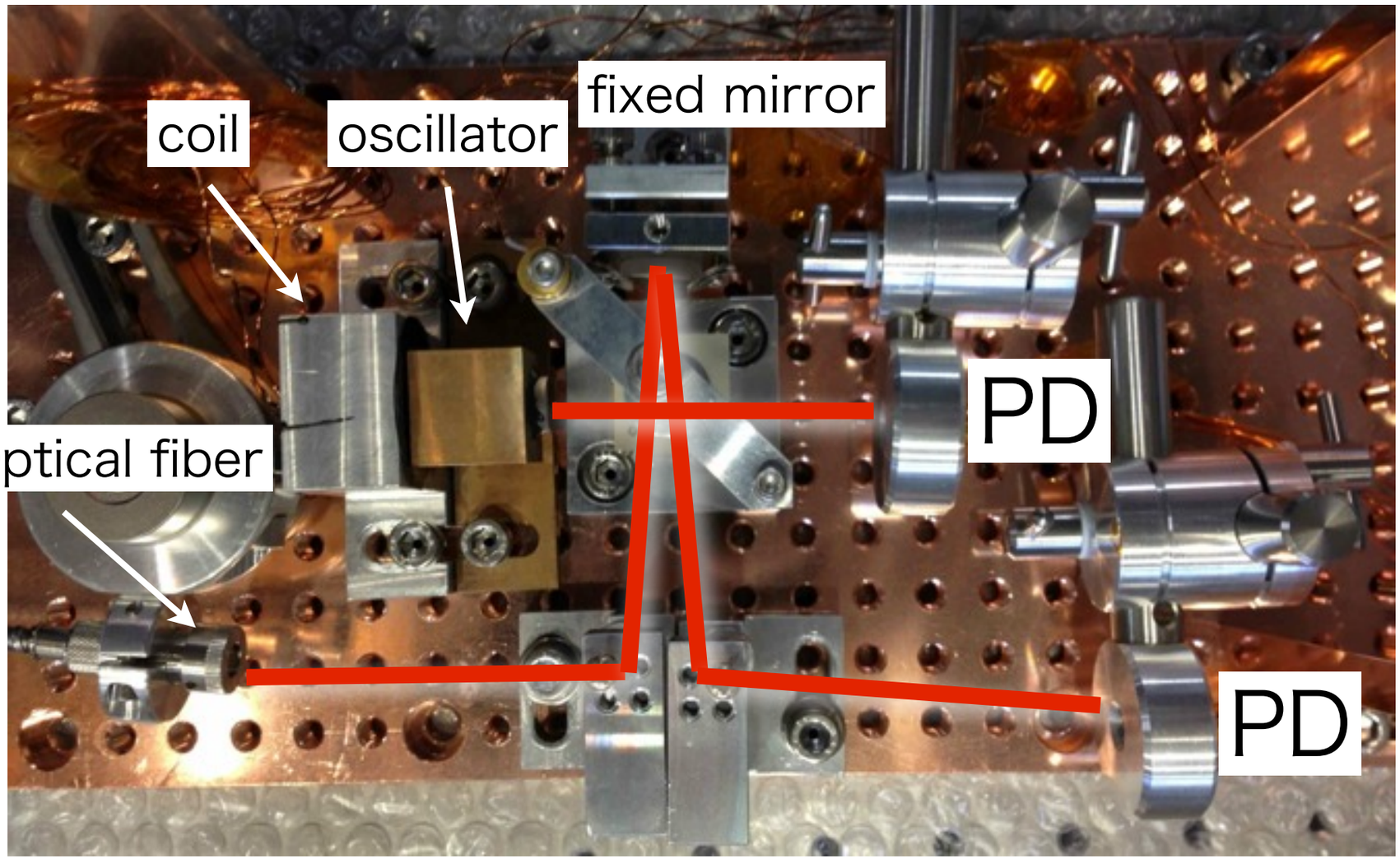
We use the signal from two PDs to control one mirror (oscillator) of the Michelson interferometer.

Pictures of the accelerometer



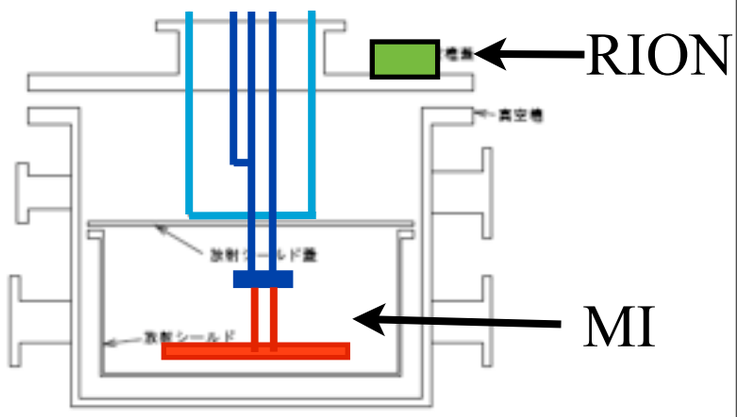


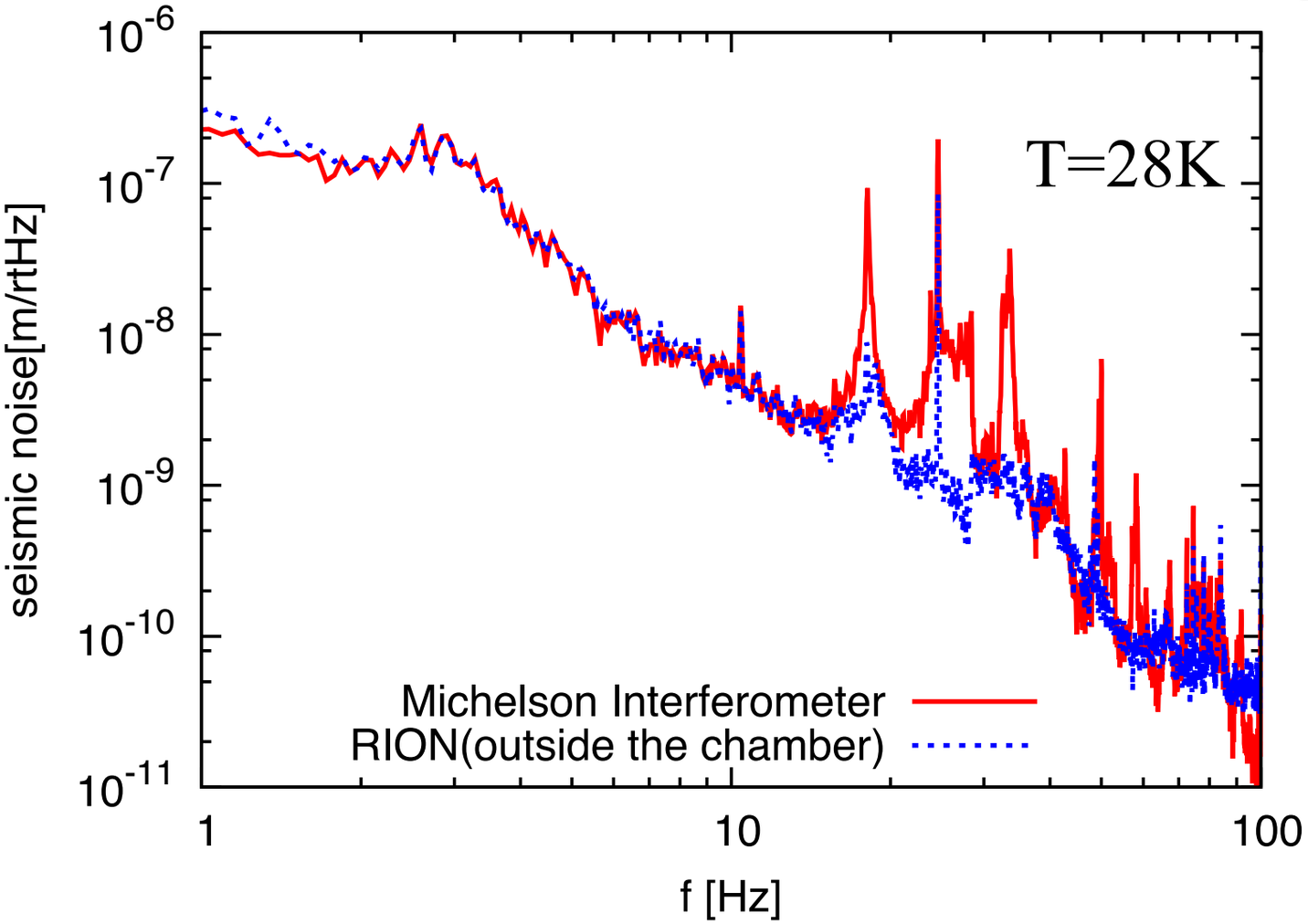
oscillator



We used a coil actuator to control the Michelson Interferometer

Cooling test of the accelerometer



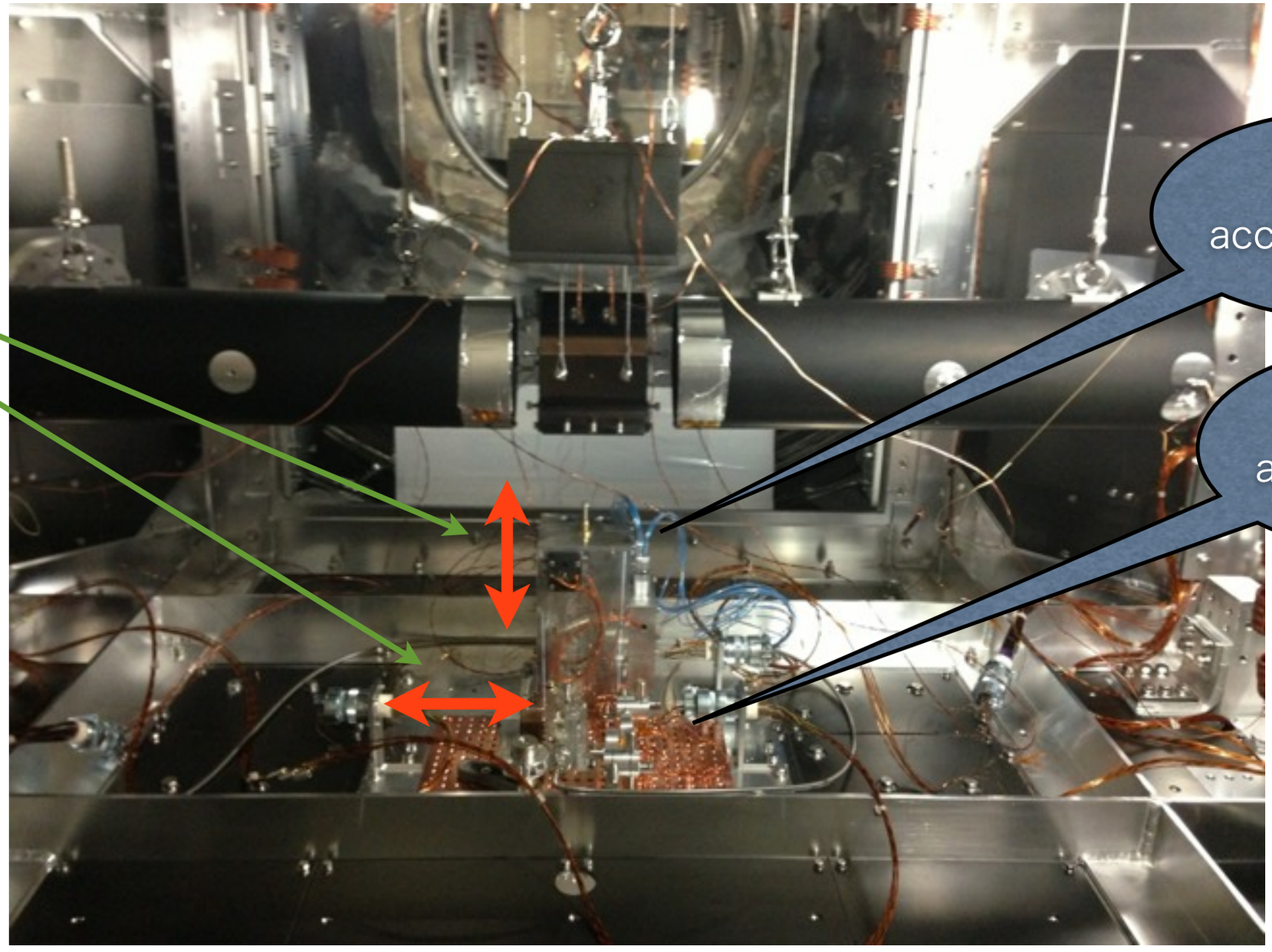


We compare the output of the Michelson interferometer and that of the RION.

The signals are consistent with each other especially at low frequency.

The measurement in Toshiba

Measurement axis



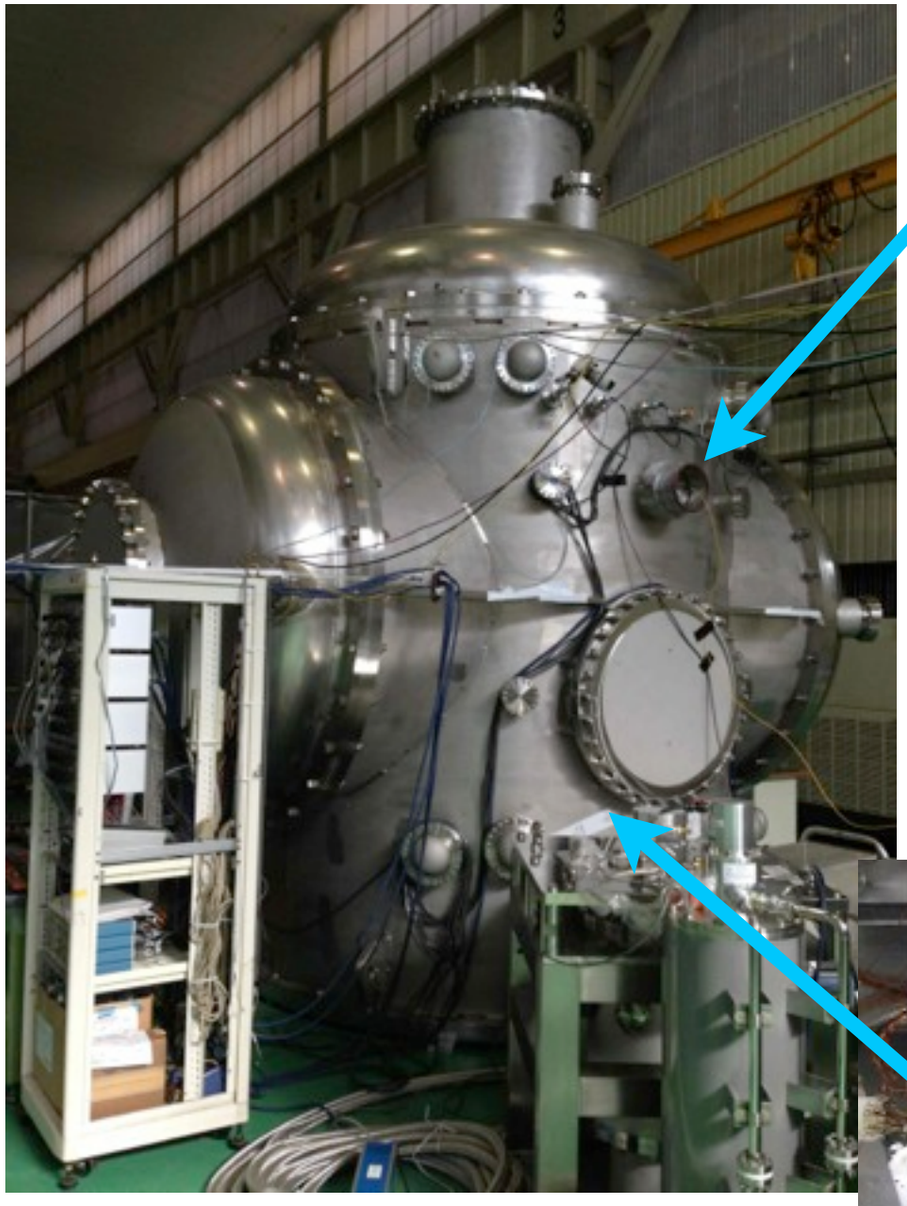
Cryostat #3

Accelerometers

One is for the vertical component.

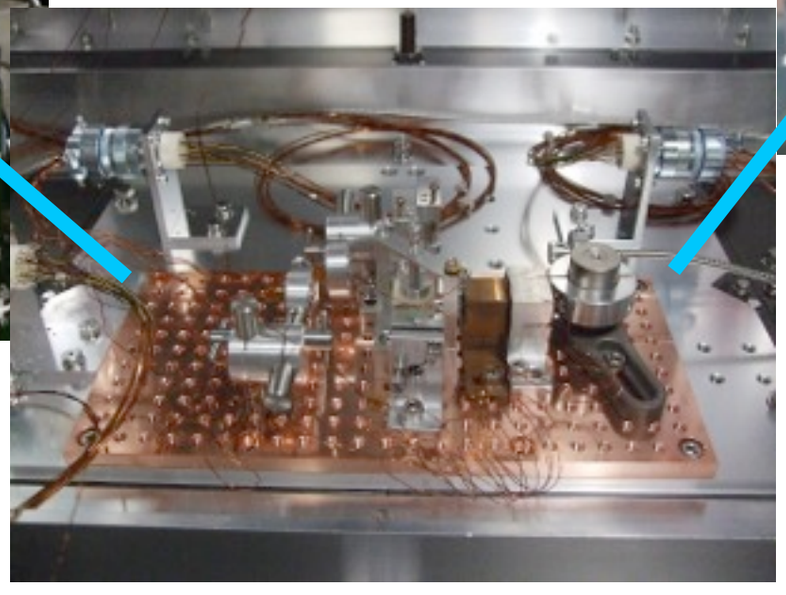
The other one is for the horizontal component.

Installation of the accelerometer into the KAGRA radiation shield



The cryostat

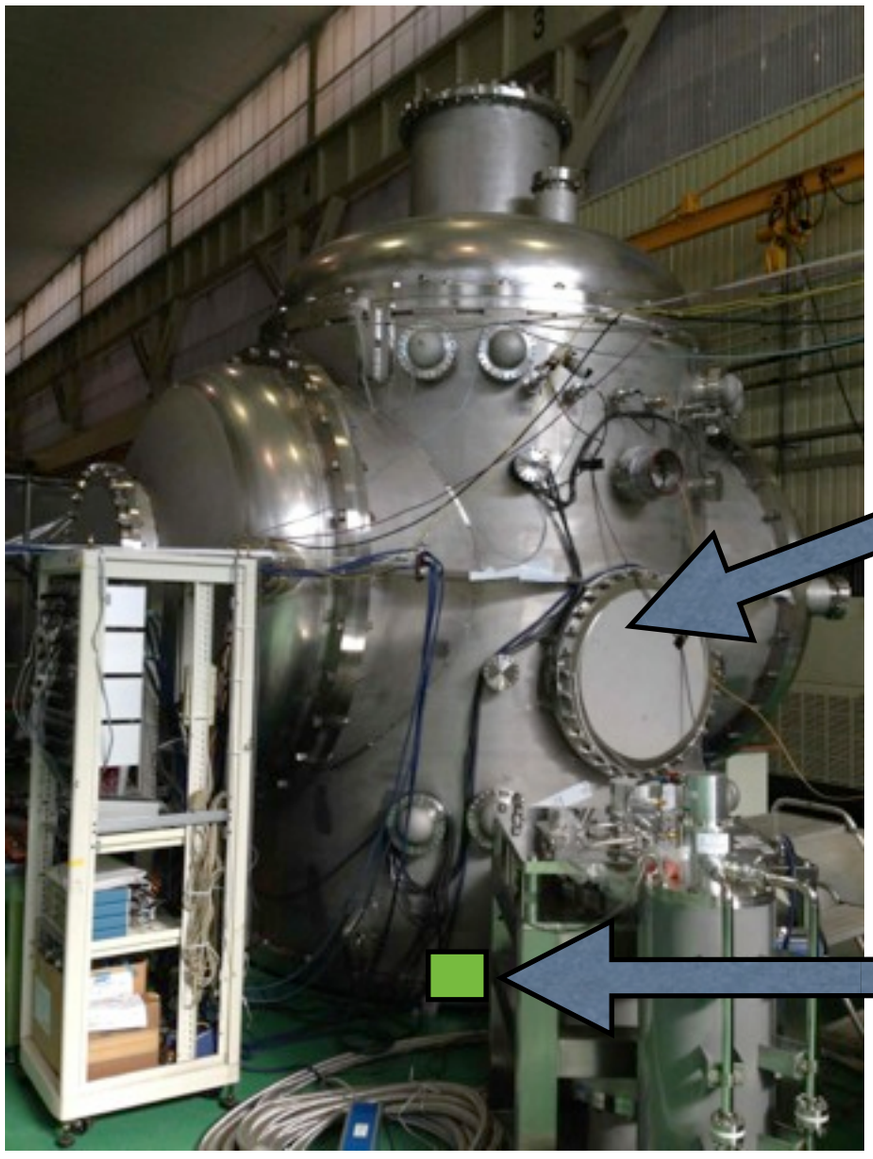
Optical fiber port

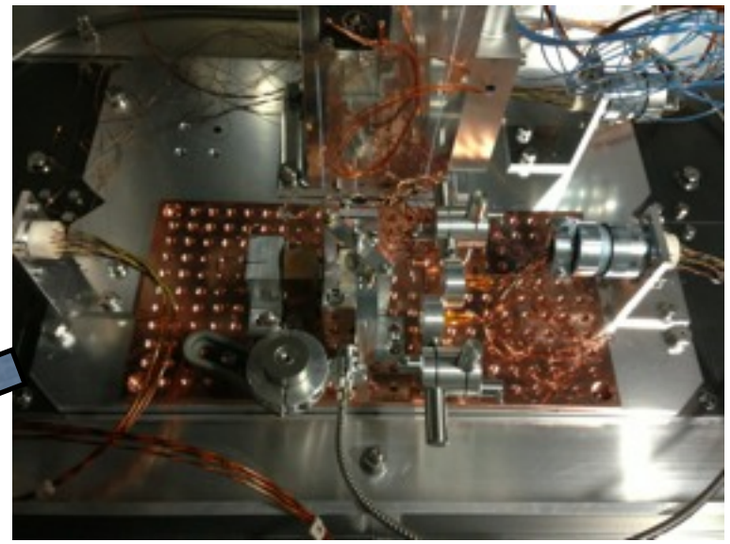


The ICRR accelerometer

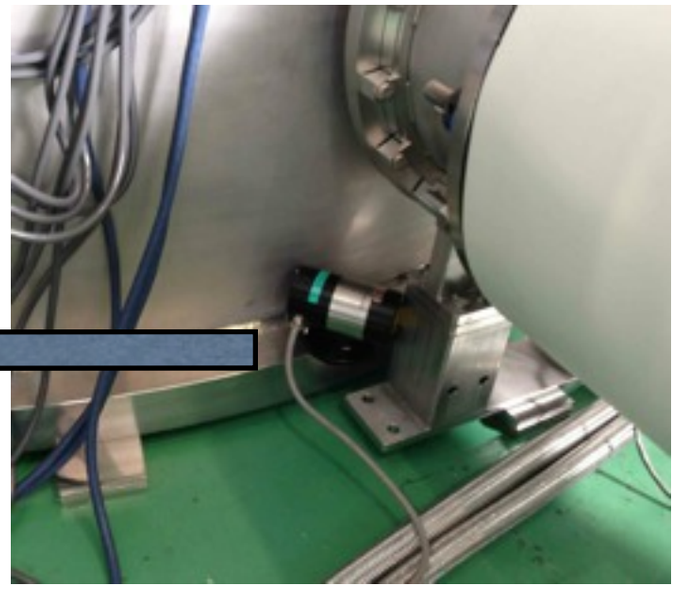
Inside of the radiation shield

Installation of the accelerometer into the KAGRA radiation shield





Our accelerometer



RION

We used a commercial accelerometer(RION) to measure the vibration outside the cryostat.

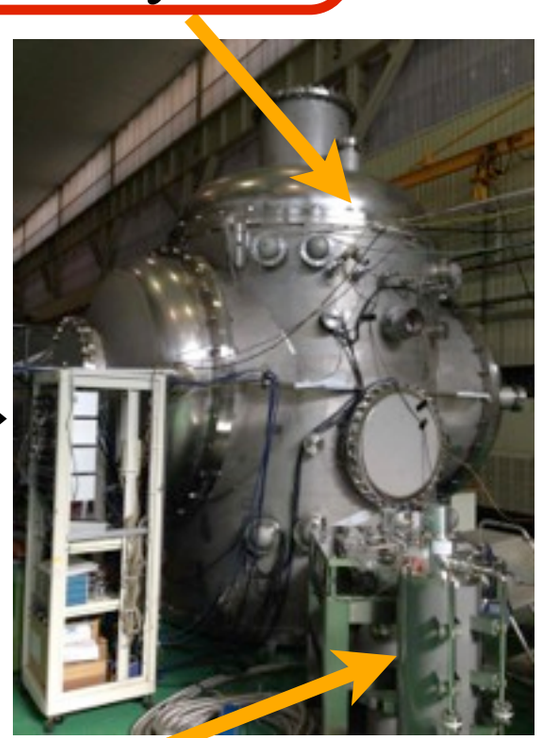
Vibration measurement during cooling

Purpose

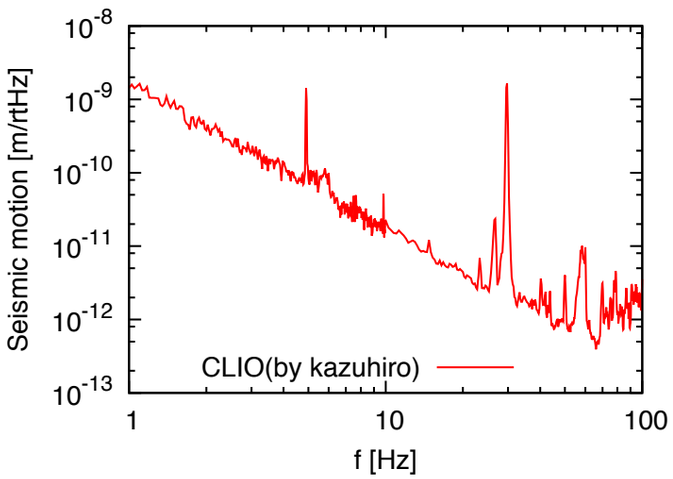
Estimation of the vibration in the cryostat at Kamioka mine during cooler operation.

The structure of the cryostat

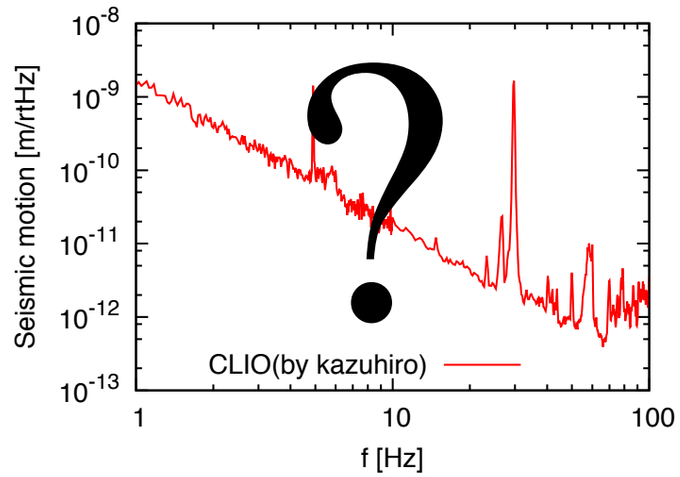
Measure the vibration both of inner shield and outside the chamber



Seismic vibration at Kamioka



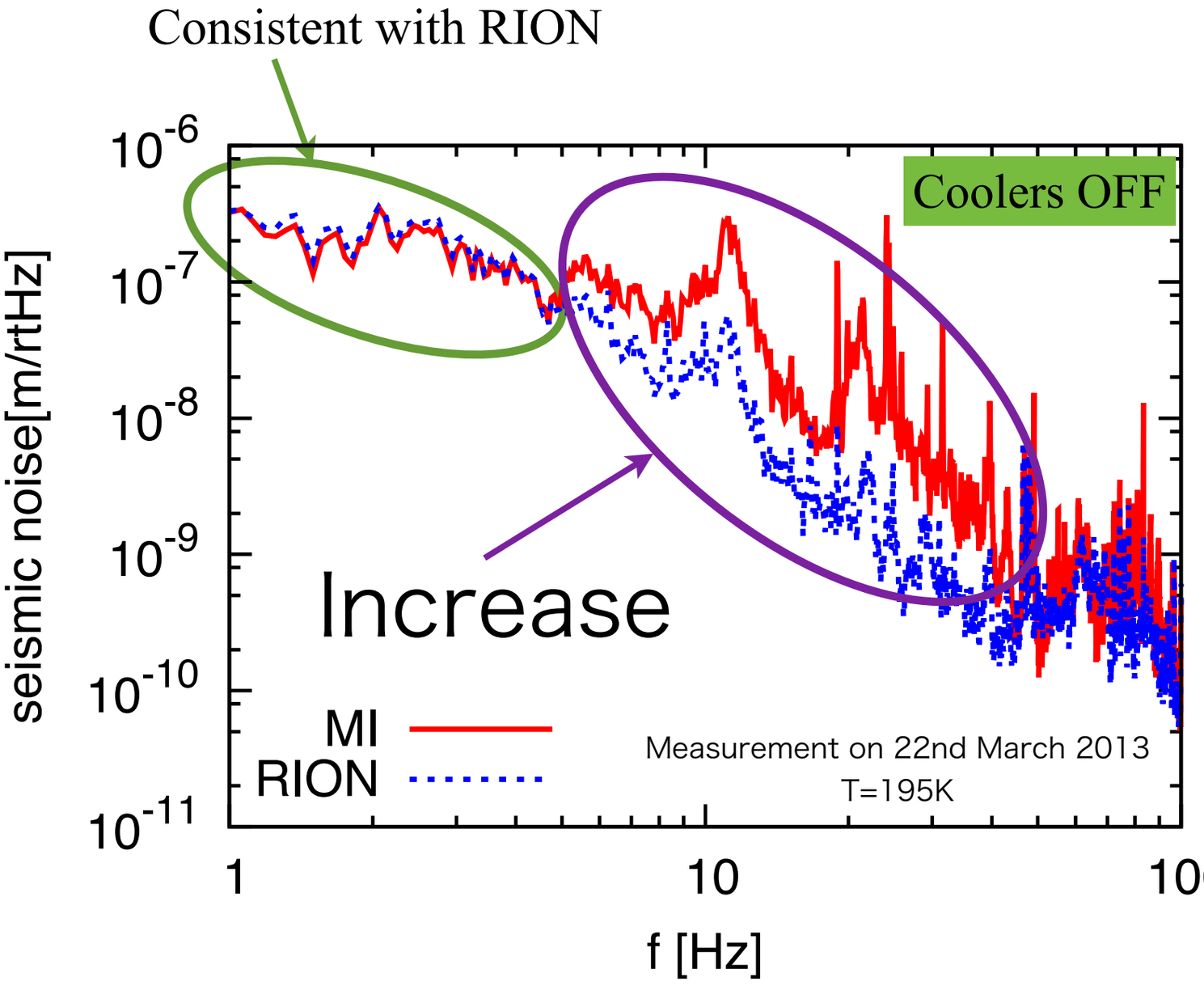
Vibration in the cryostat at Kamioka

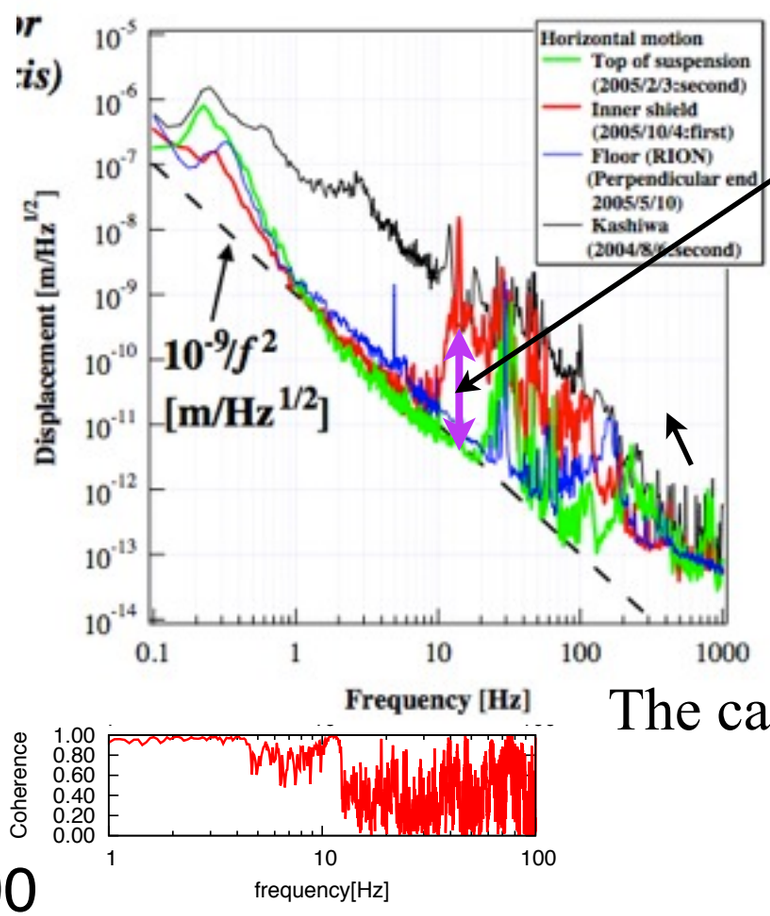


The vibration of the coolers

Measure the vibration with coolers ON/OFF

Vibration measurement during cooling



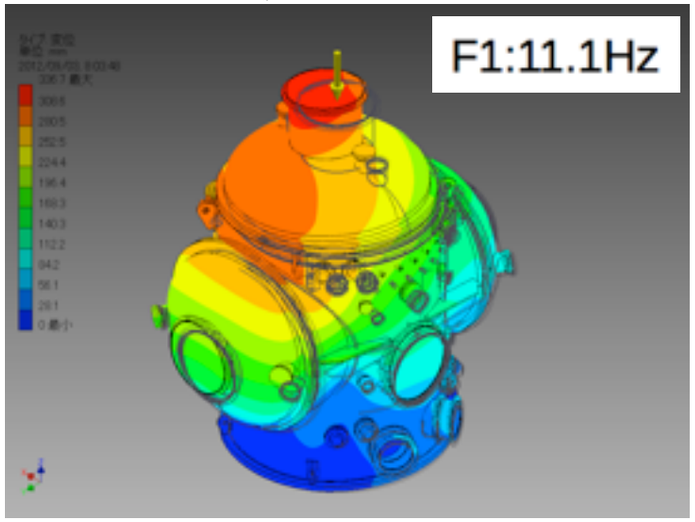


The case of CLIO

We had coincidence measurements with RION.
The signals of these two accelerometers are consistent at low frequency.
Around 10Hz, the vibration increases by ~10 times (smaller than CLIO).

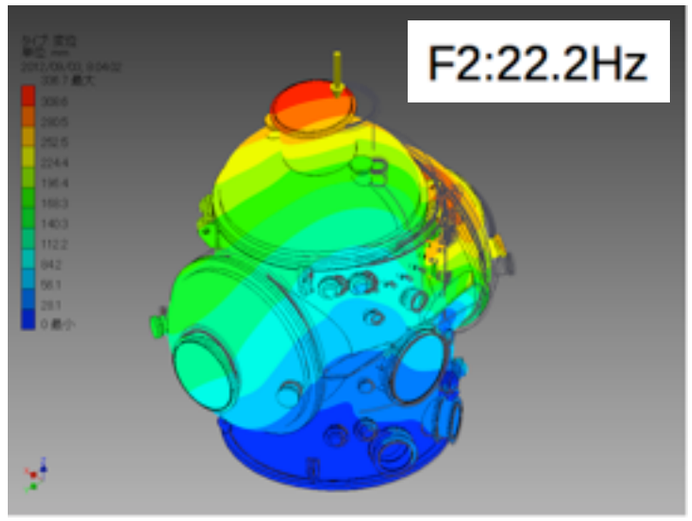
Modal Analysis of the Cryostat

(KEK Shigeaki Koike)



mode frequency

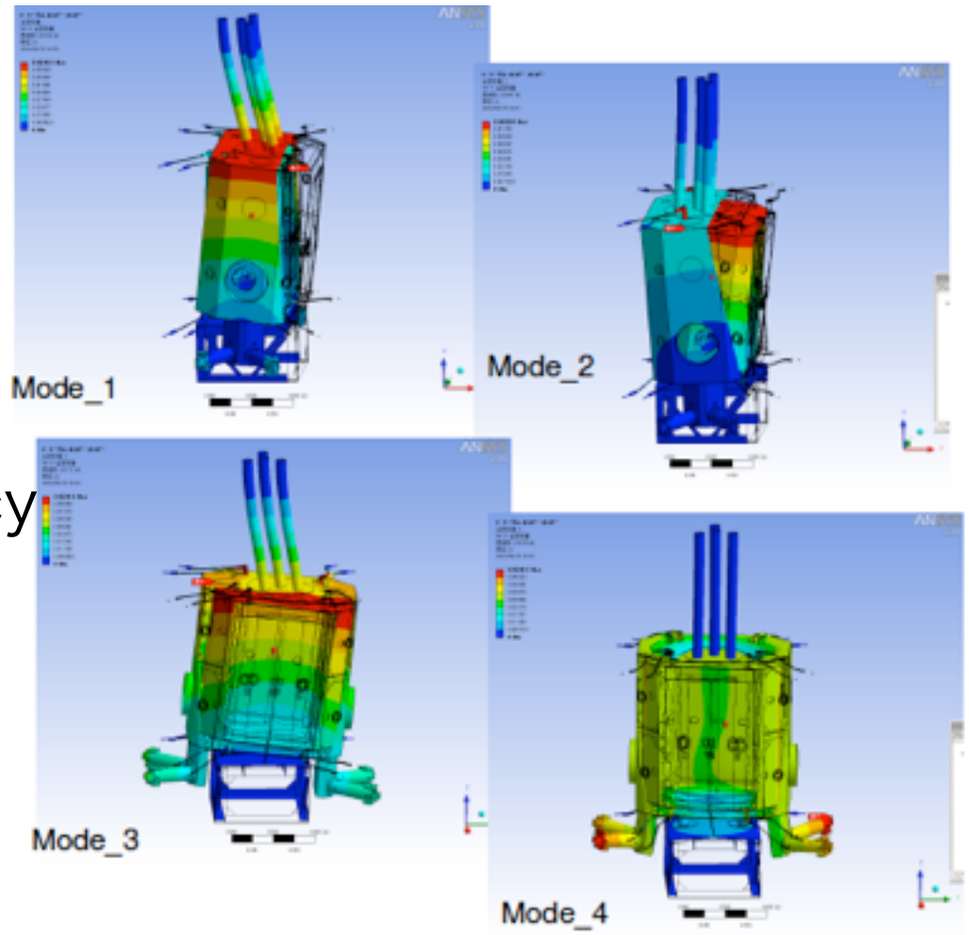
F1	11.07 Hz
F2	22.22 Hz
F3	34.72 Hz
F4	38.03 Hz
F5	43.02 Hz
F6	44.81 Hz
F7	55.97 Hz
F8	56.14 Hz



Vibration of
the vacuum chamber

mode frequency

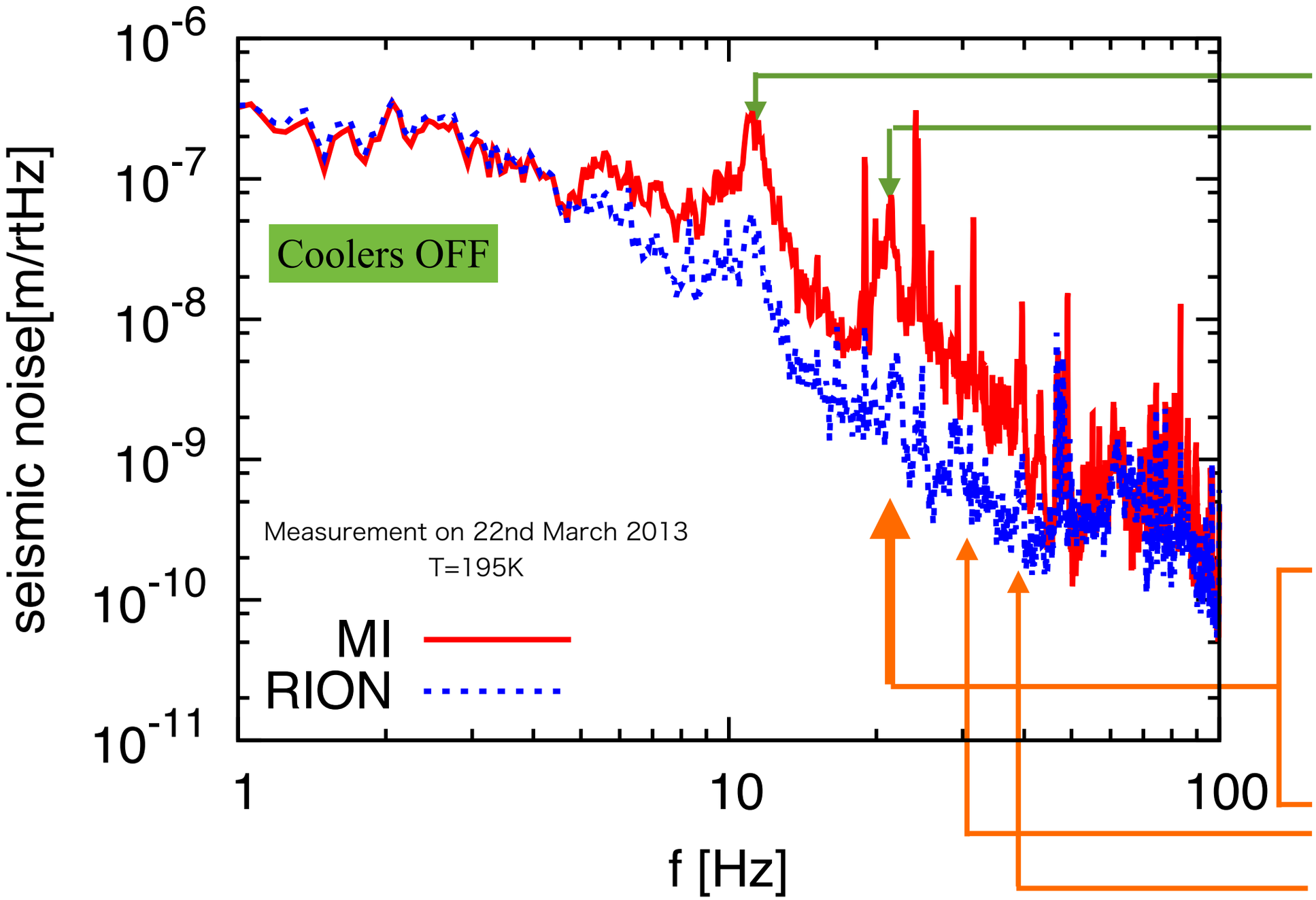
F1	20.709
F2	23.947
F3	24.712
F4	24.878
F5	30.839
F6	38.156
F7	42.182
F8	45.09



Vibration of the radiation shield

We calculated the resonance peaks of the chamber and the radiation shield

Vibration measurement during cooling



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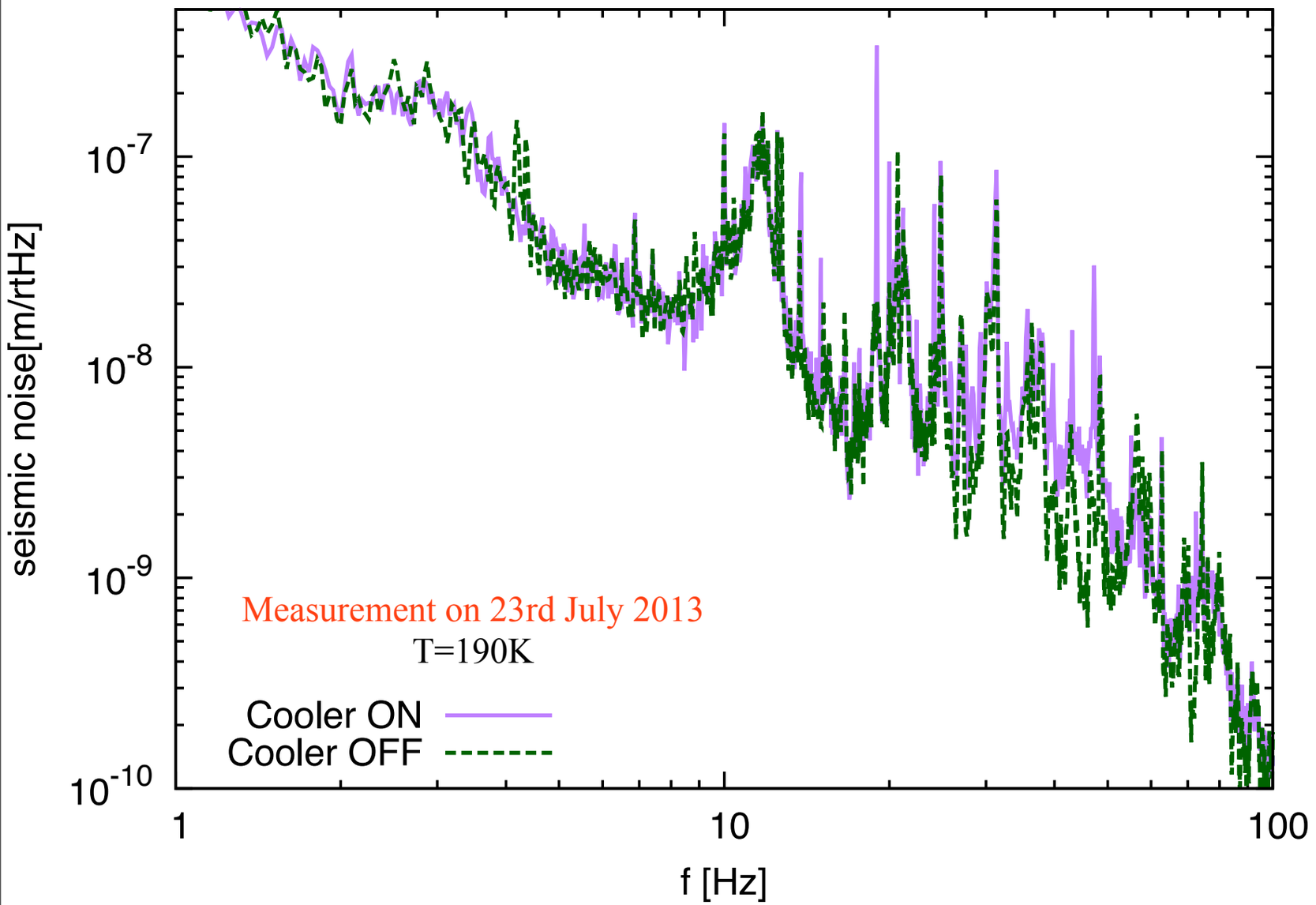
Vibration of the radiation shield

The measurement is consistent with many calculated peaks.

Vibration measurements during cooling

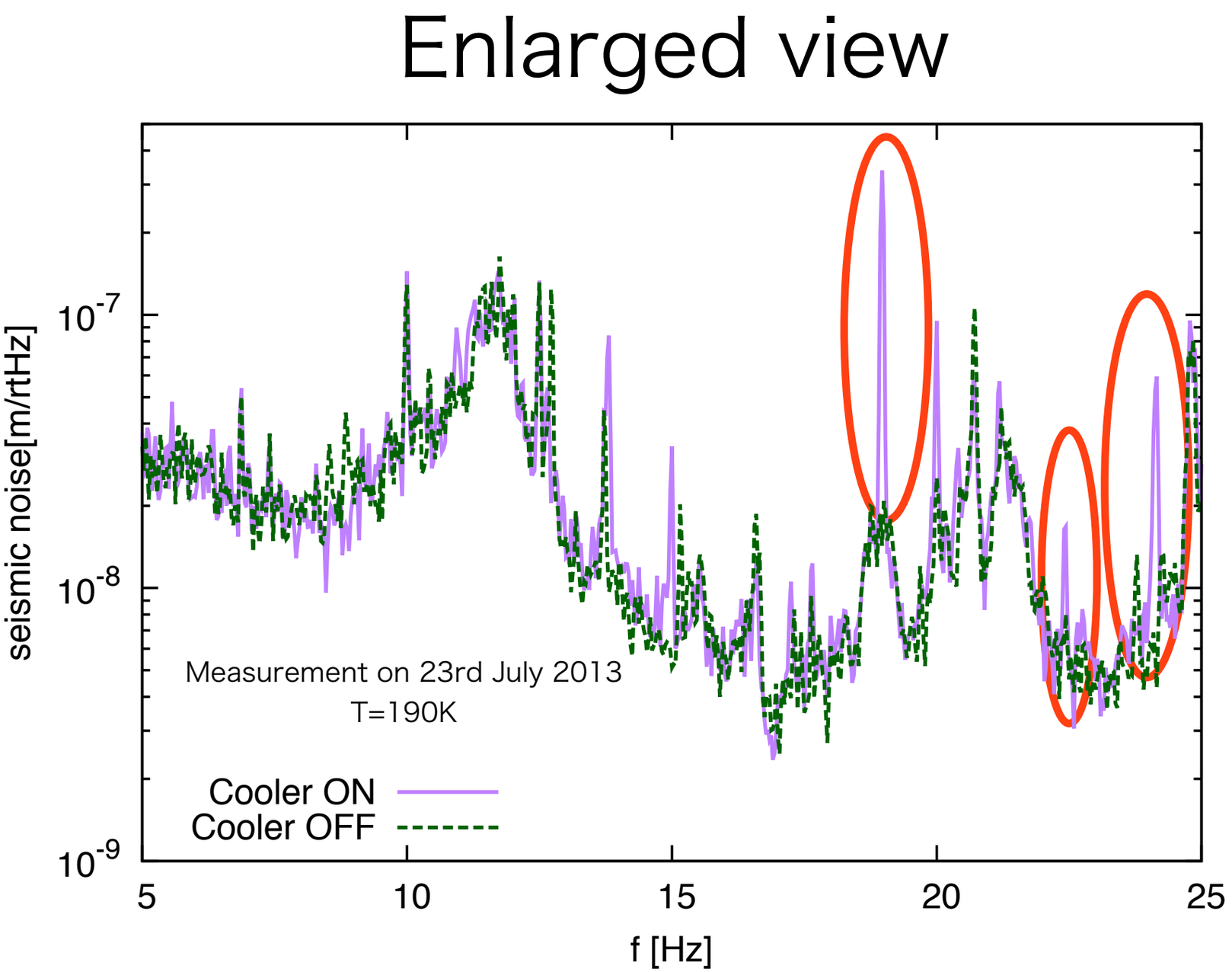


We want to know
the influence of coolers

We measured the
vibration with coolers
ON/OFF

There is no huge change of the vibration floor level,
but...

Vibration measurements during cooling

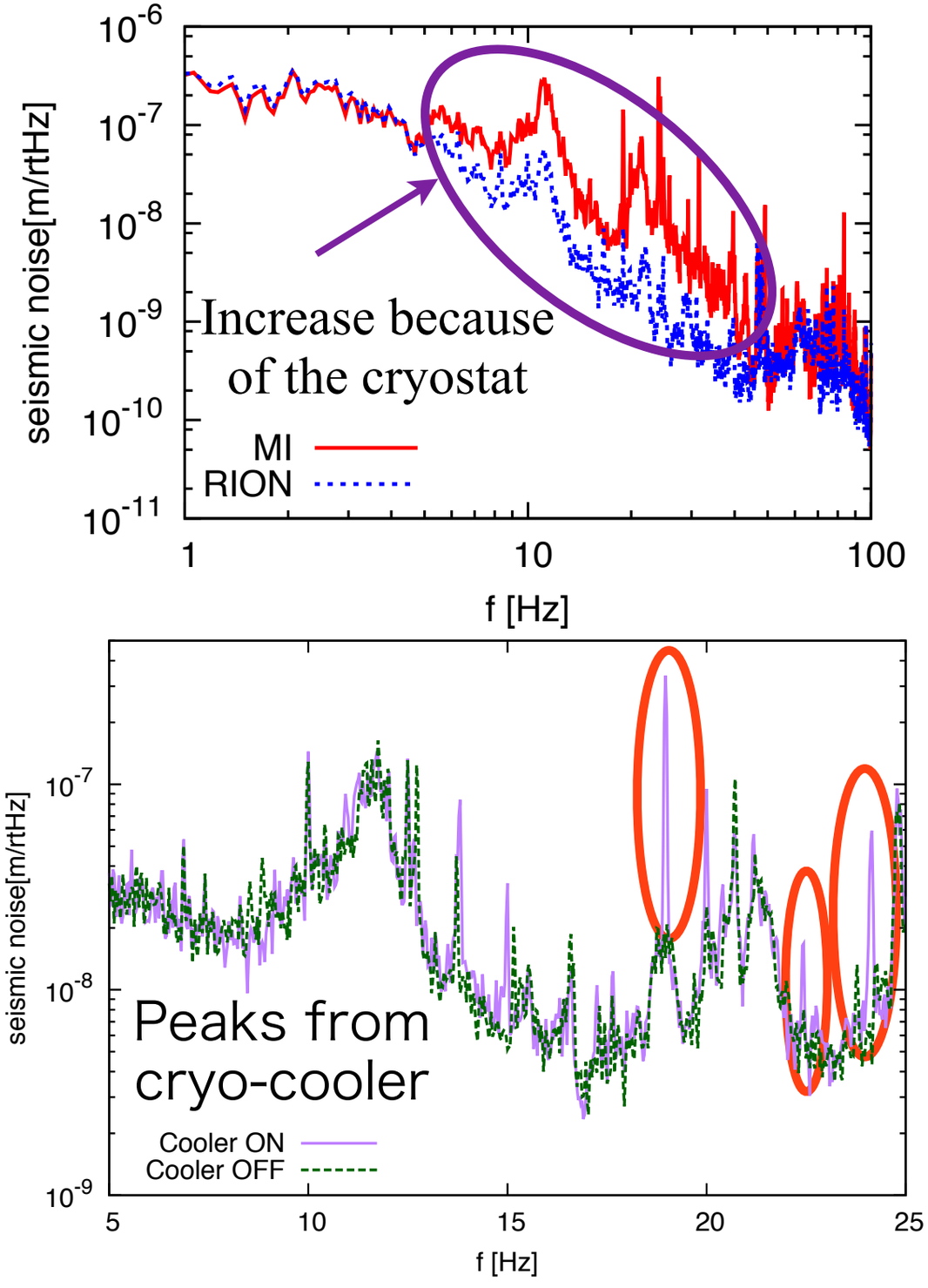


We want to know
the influence of coolers

We measured the
vibration with coolers
ON/OFF

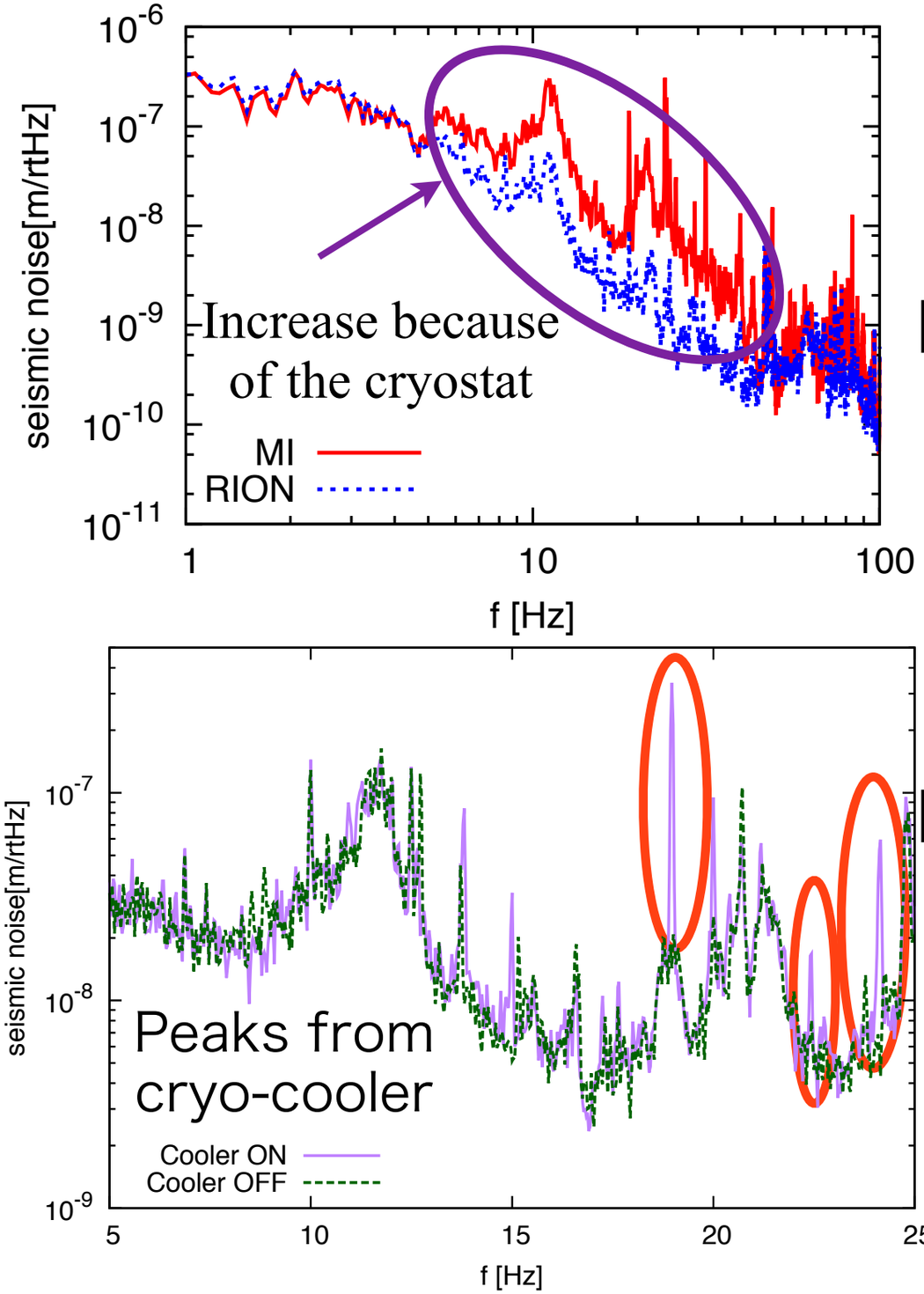
We can see many peaks originating from the cryo-coolers.

The impact on the sensitivity of KAGRA



We calculated the interferometer noise resulting from this vibration.

The impact on the sensitivity of KAGRA

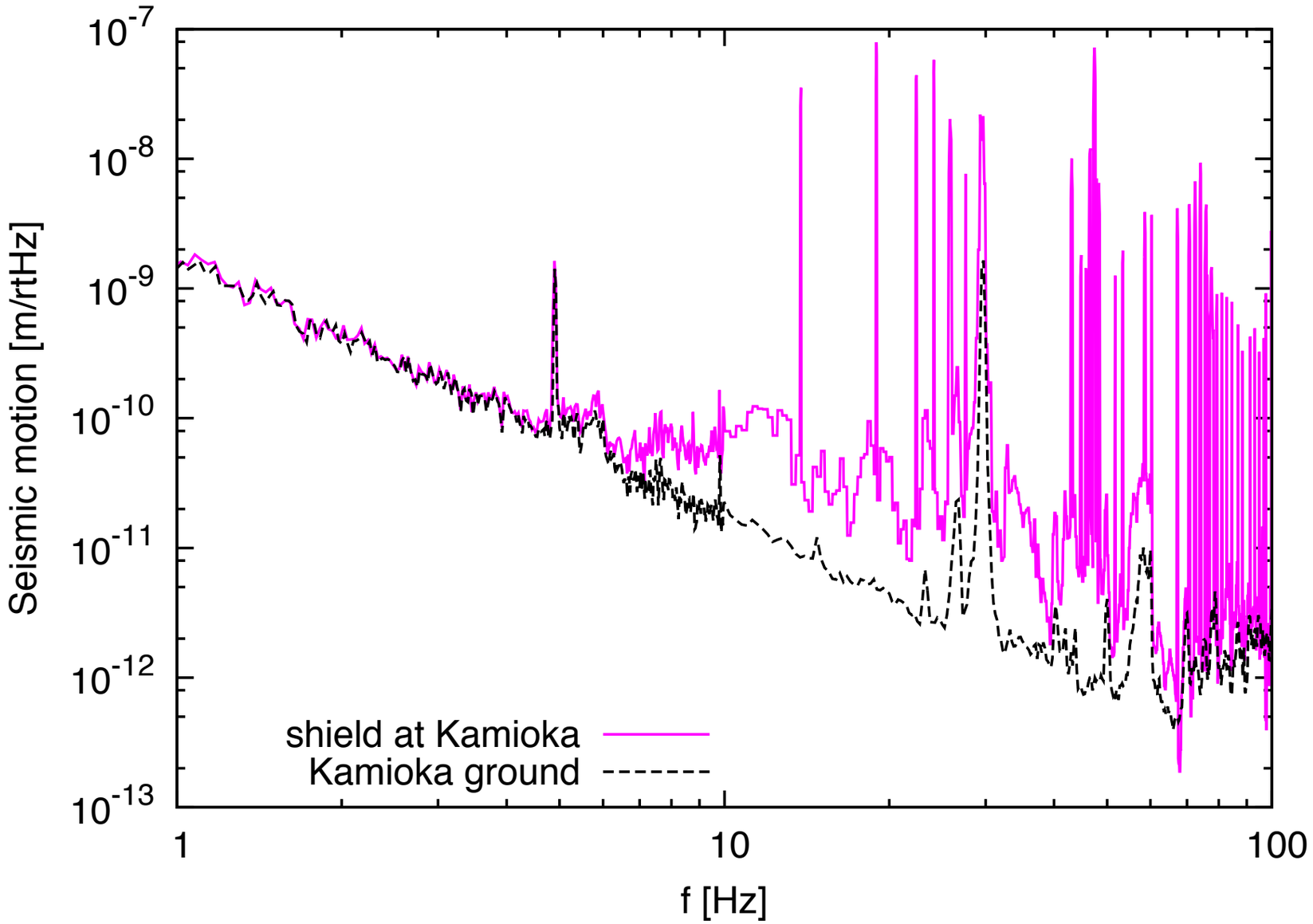


Calculate the ratio to estimate the floor level at Kamioka.

Assume the same peak level at Kamioka as Yokohama

The vibration of the radiation shield at Kamioka

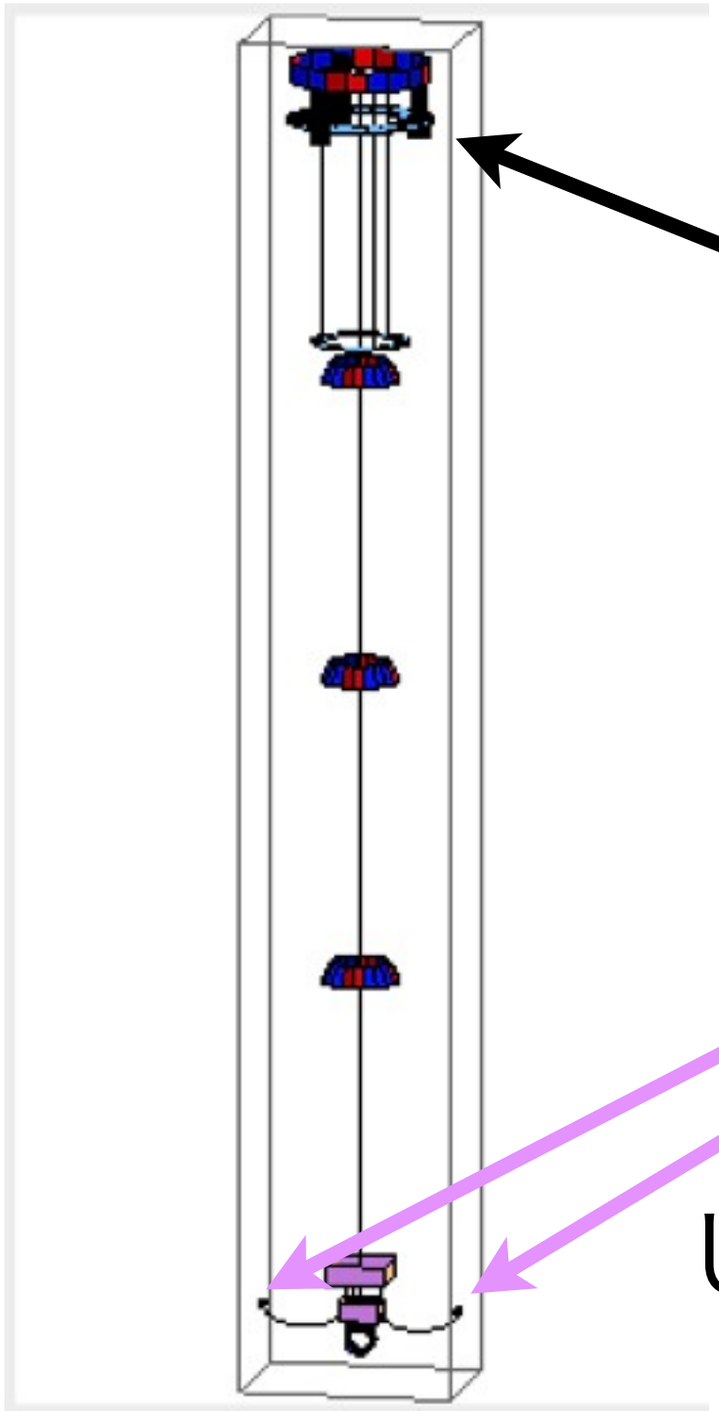
The impact on the sensitivity of KAGRA

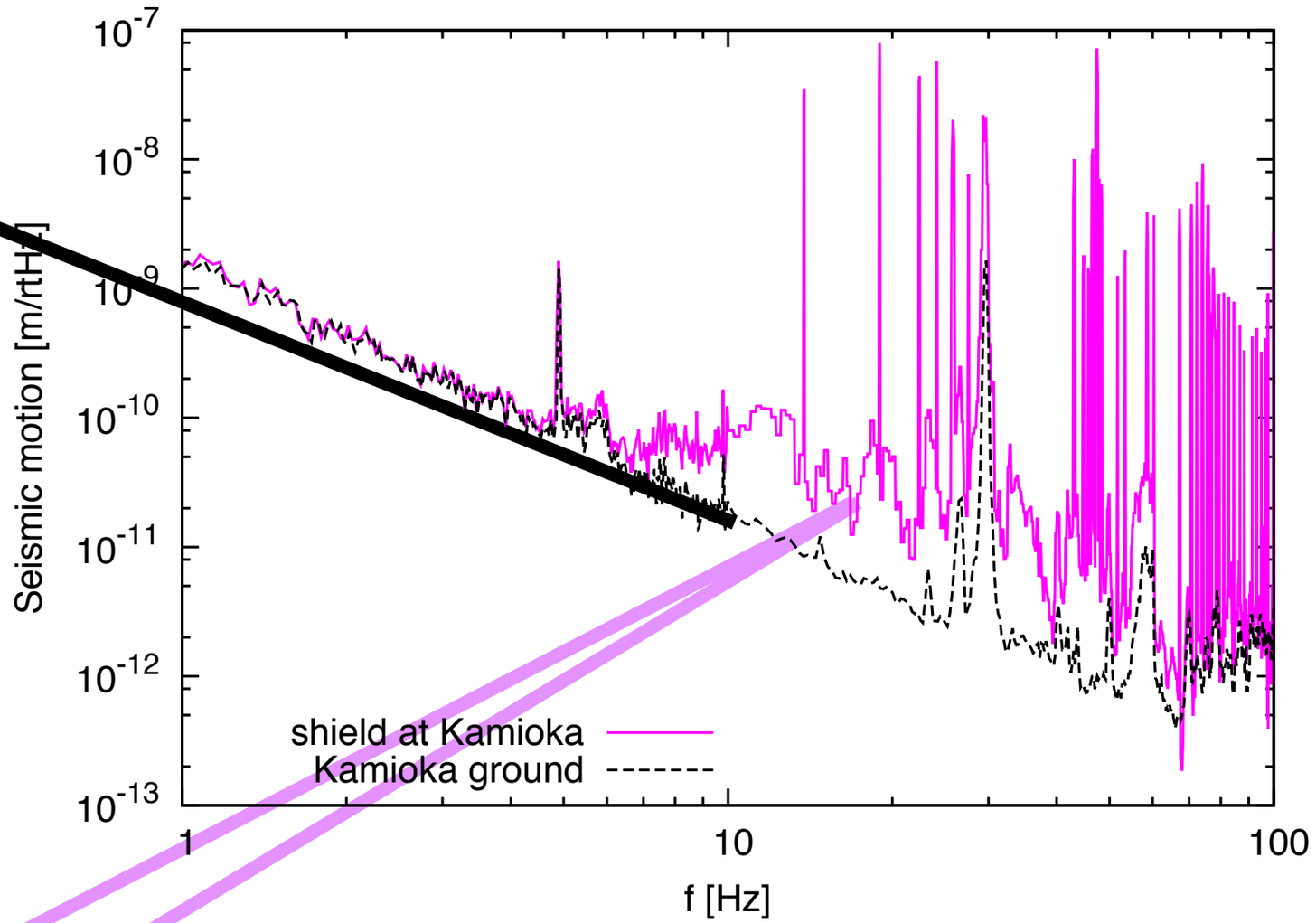


The estimated vibration of the radiation shield at Kamioka

Calculate the influence on the sensitivity of KAGRA

The impact on the sensitivity of KAGRA



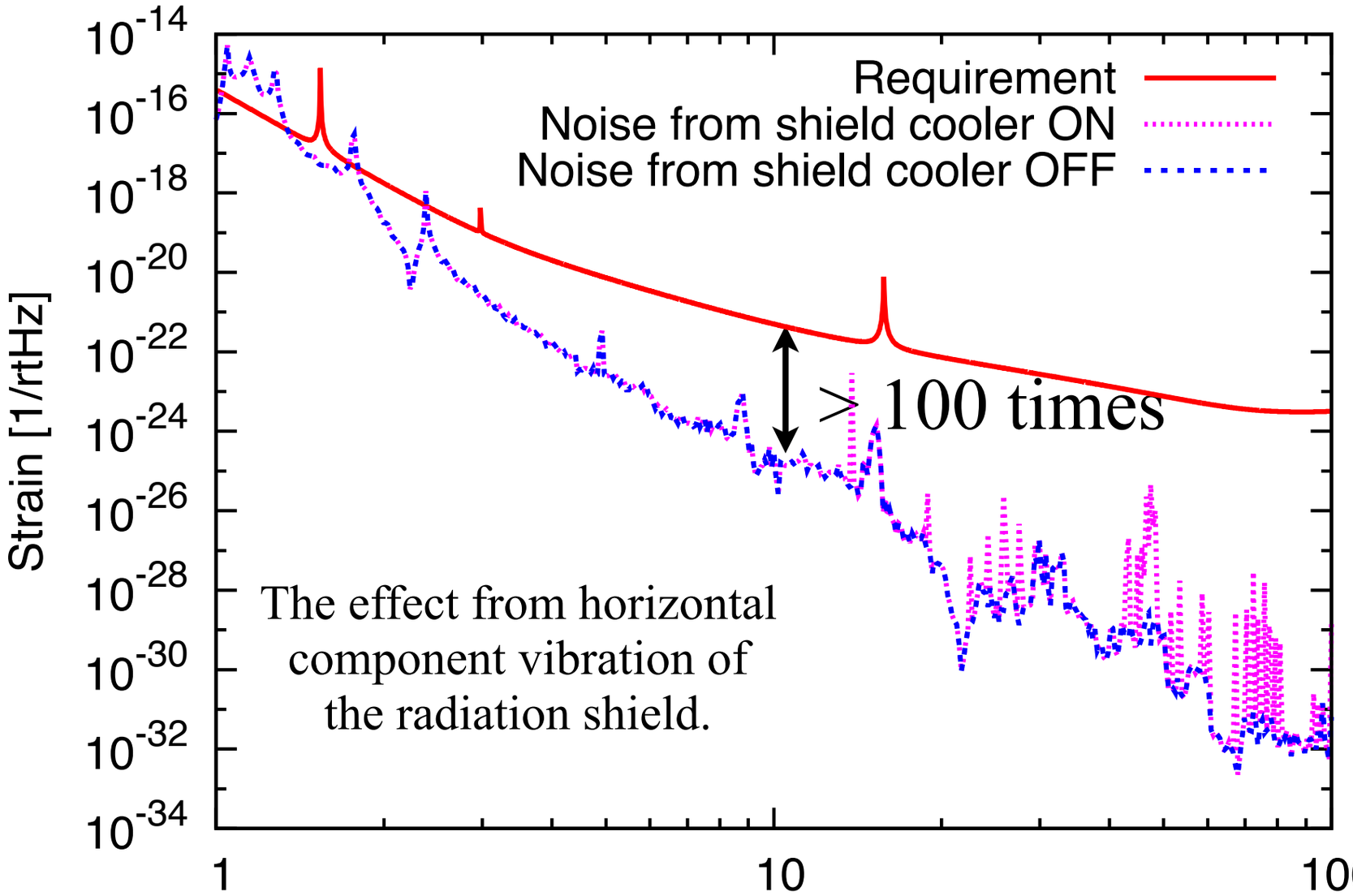


Input to the heat links

Use the code of T. Sekiguchi

The scattered light effect is not considered.

The impact on the sensitivity of KAGRA

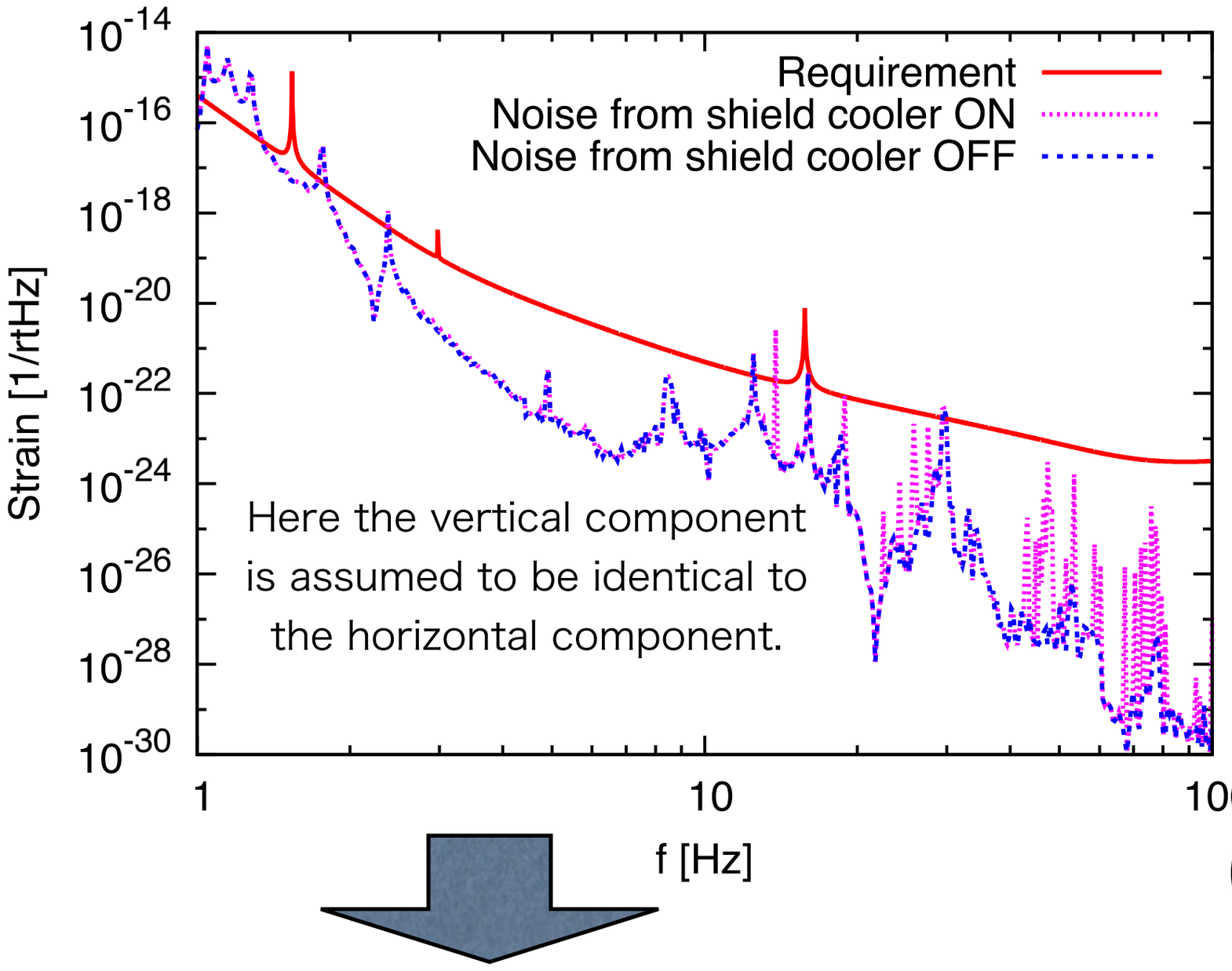


Supported by K. Ono

The noise from the horizontal vibration component is significantly lower than the requirement.

The impact on the sensitivity of KAGRA

preliminary



Supported by K. Ono

We have to take care of these peaks when we design the cryo-payload.

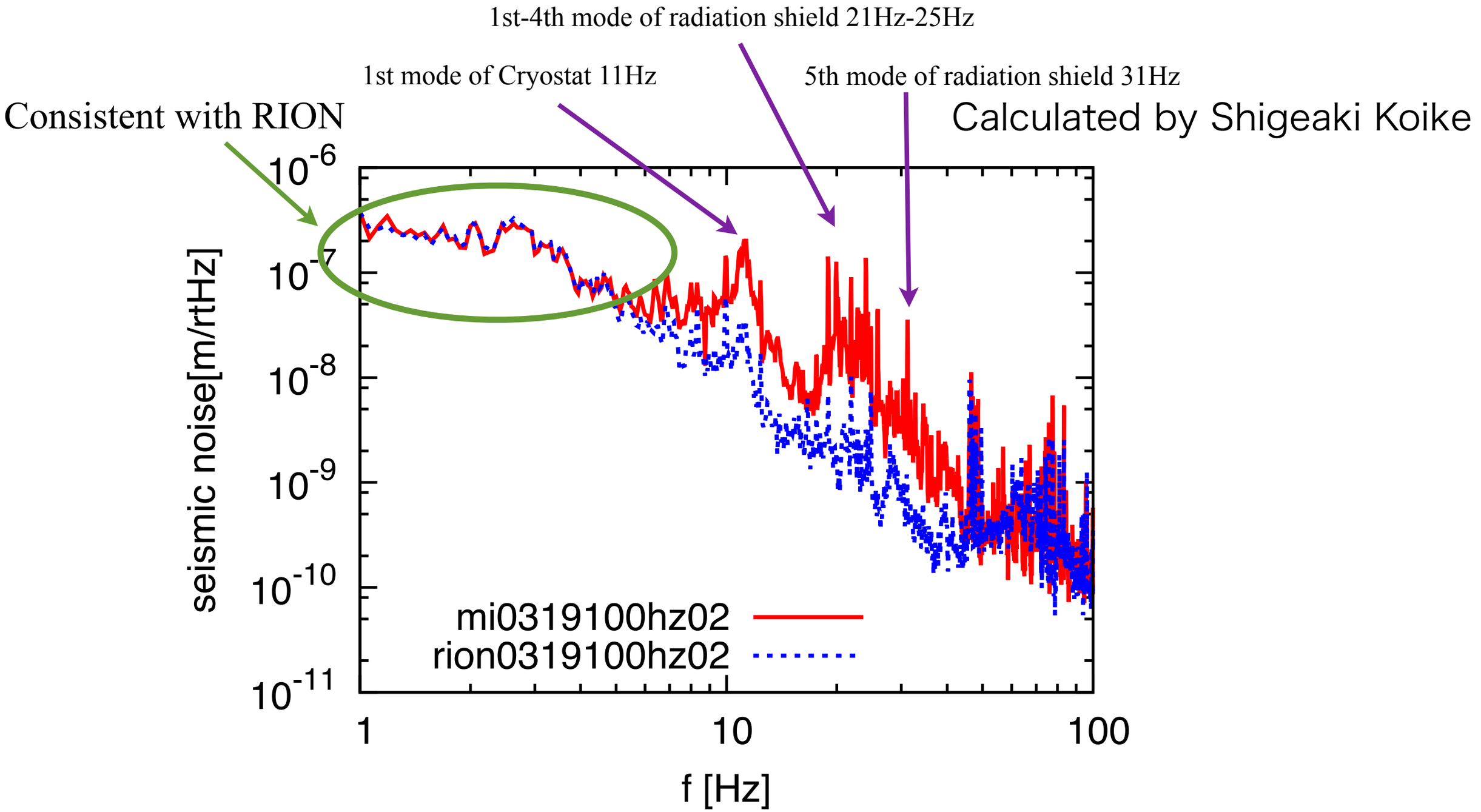
The floor level has 1-2 order margin.
But several peaks are higher than the requirement.
Analysis of Luca's data is in progress.

Summary and future works

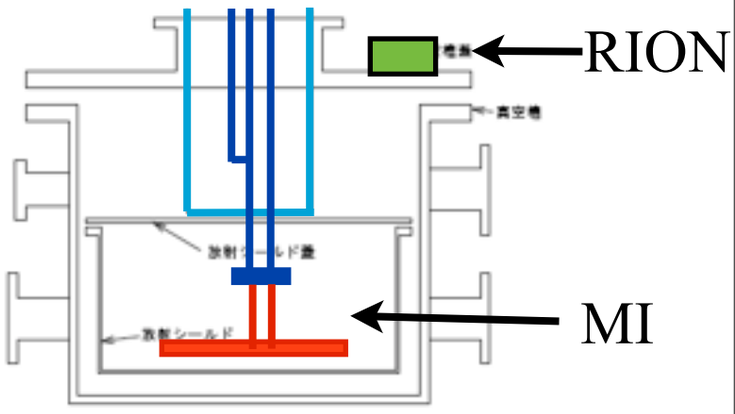
- We have measured the vibration in the radiation shield during the coolers operation.
- From the data, we estimated the vibration in the radiation shield at Kamioka.
- The estimated noise from heat links is lower that the requirement. (In the case of horizontal component.)
- We are analyzing the vertical component.
- We will calculate the influence from scattered light.

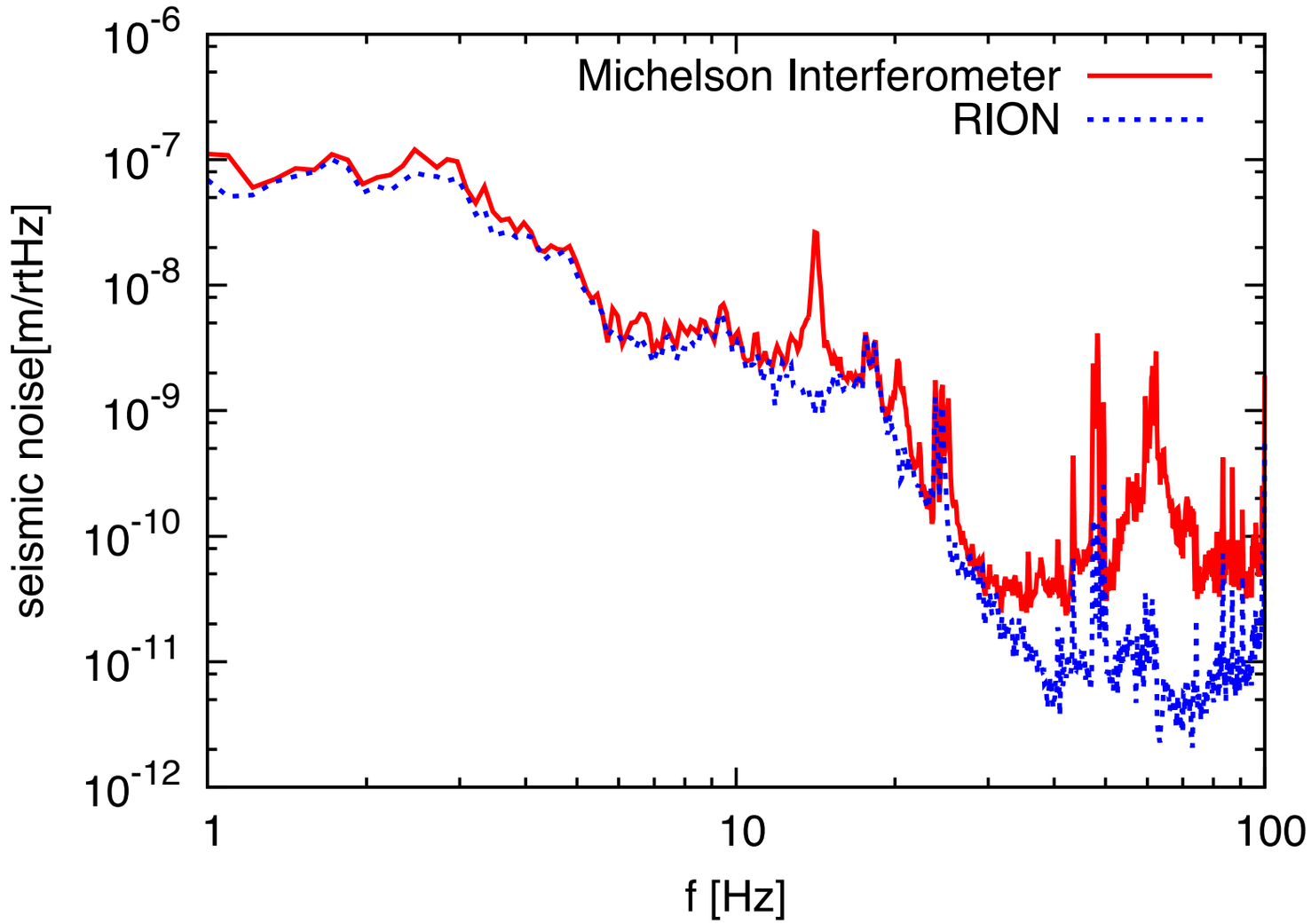
End

Measurement at T=250K



The cooling test of the accelerometer





T=281K
with magnet