Investigation of Crackling Noise in the vibration isolation system of KAGRA (1)

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Outline

- KAGRA and its vibration isolation system(VIS)
- The concept of crackling noise and crackling noise in GAS filter
- Crackling noise experiment
- Summary

KAGRA

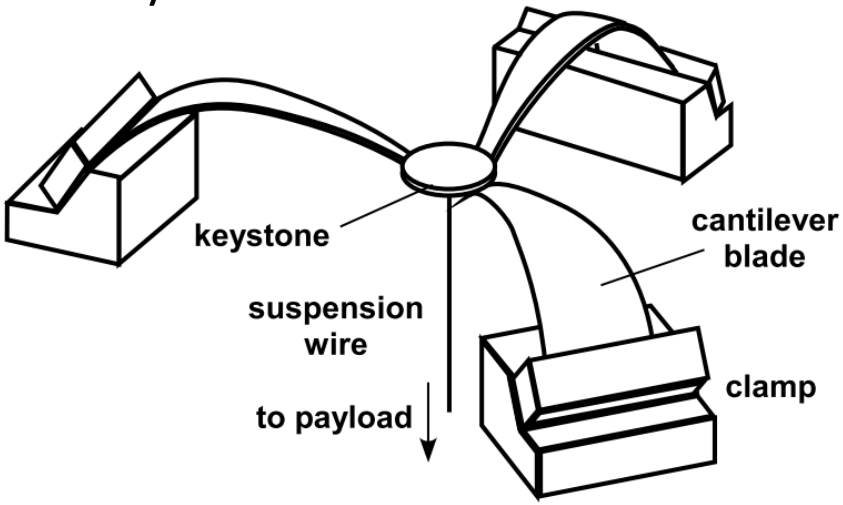
KAGRA is the 2nd generation 3km interferometric GW wave detector in Japan with features of

- Underground site
- Cryogenic operation

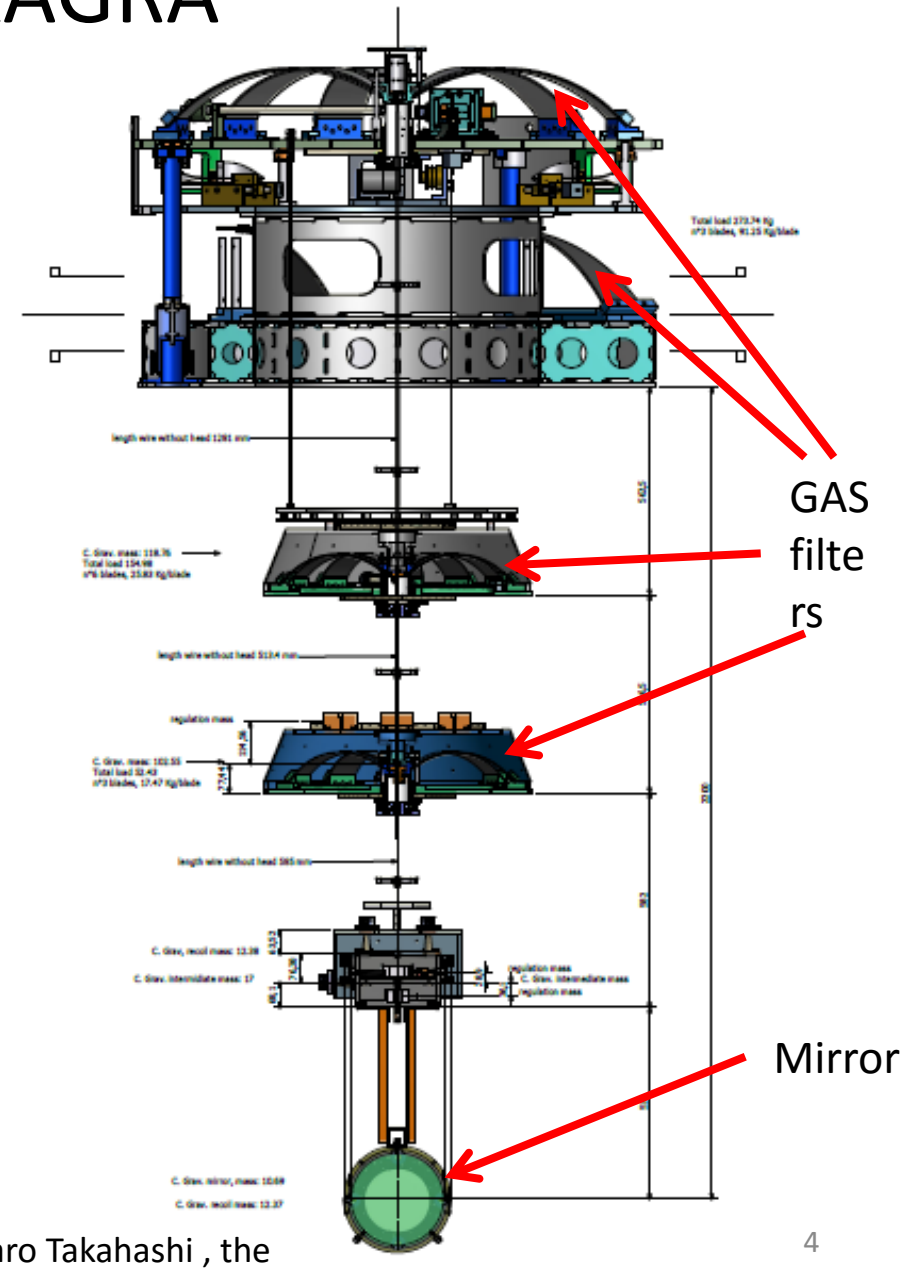
The observation run will start at the end of F.Y. 2017.

VIS in KAGRA

- The main optics of KAGRA are isolated from seismic vibration by VIS(Vibration Isolation System).
- GAS (Geometric Anti-Spring) filters are tuned to a low resonant frequency to isolate the vertical seismic noise .
- It is suspected that crackling noise may arise in GAS filters.



T Sekiguchi, D thesis



Ryutaro Takahashi , the 11th f2f meeting

The general concept of crackling noise

In a wide variety of physical systems, when the response to a changing condition behaves:

- Discrete
- Impulsive

Crackling noise happens!

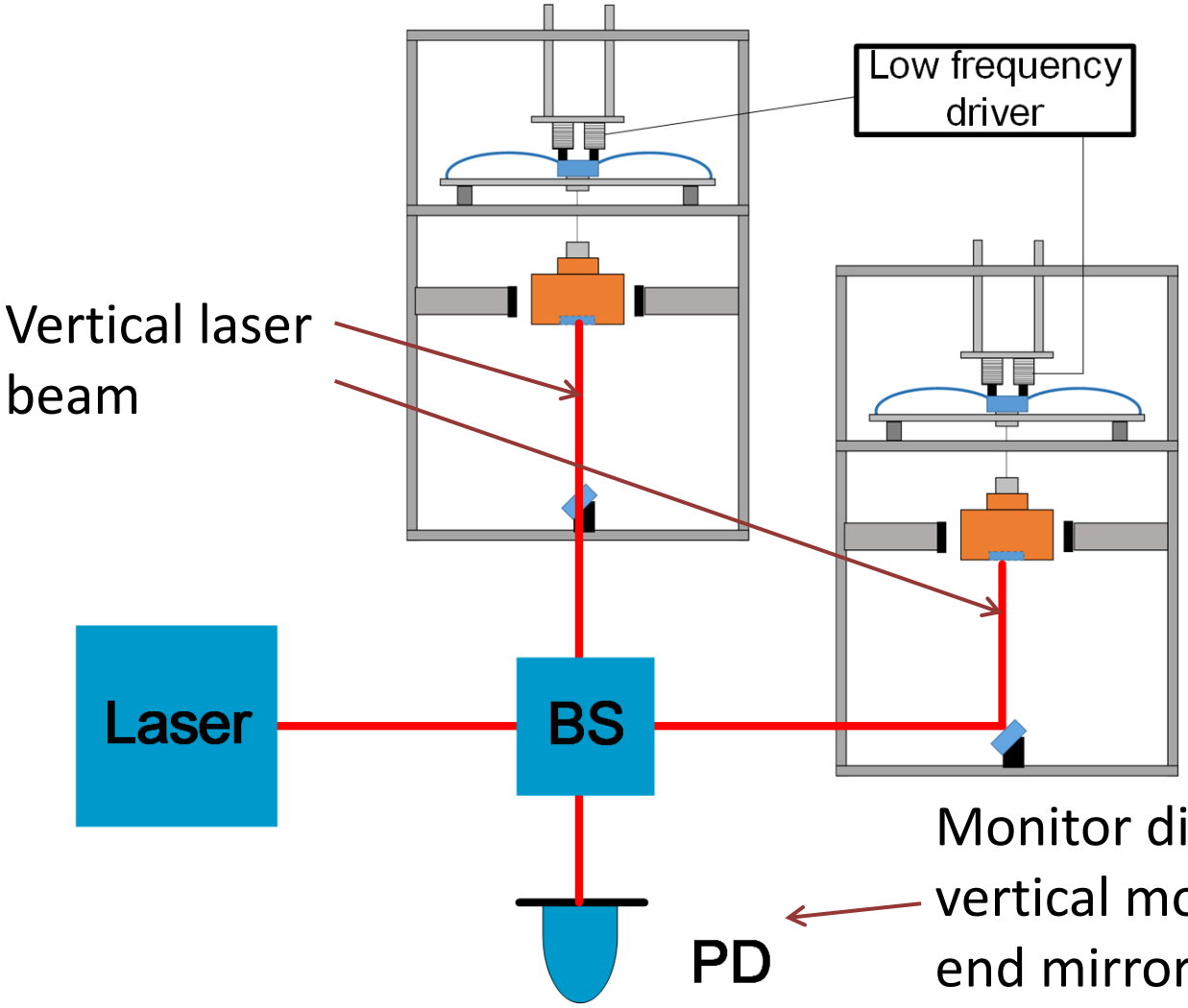
The known crackling noise includes earthquake, Barkhausen noise, etc.

Crackling noise in GAS filters

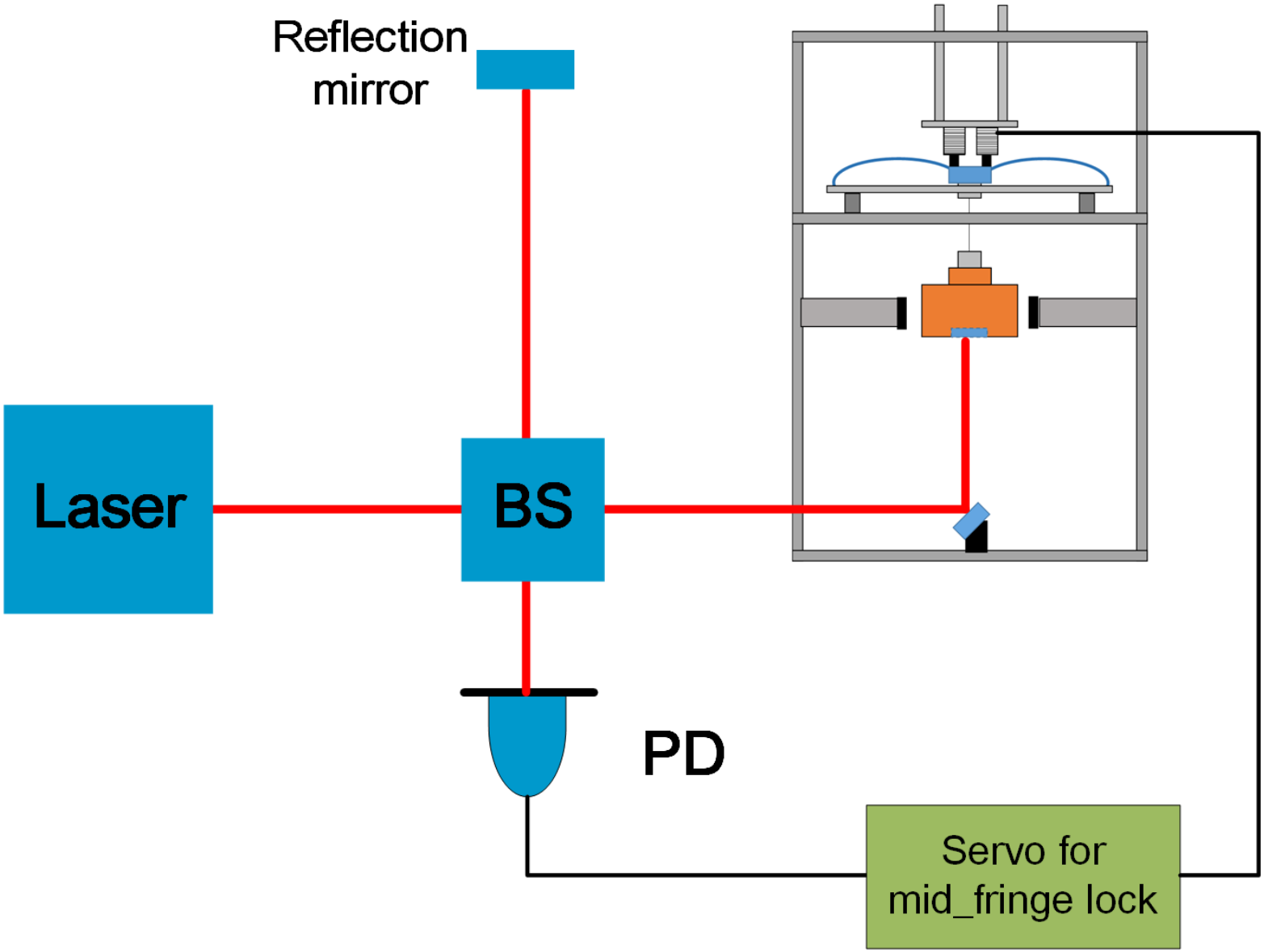
- Crackling noise may arise as a kind of discrete and impulsive motion of the blades.
- It has been observed low-frequency (on a time scale of seconds) stochastic deviations from elasticity of GAS filters*.
- Crackling noise may induce random events in the observation frequency band of KAGRA.
- Especially, the floor has a tilt of 1/300 for the water drainage system in KAGRA, so that about 0.3% vertical motion of the mirror will couple into KAGRA's readout.

* DeSalvo et.al, 2011. The role of Self-Organized Criticality in elasticity of metallic springs: Observations of a new dissipation regime. *The European Physical Journal Plus*, *126*(8), pp.1-39.)

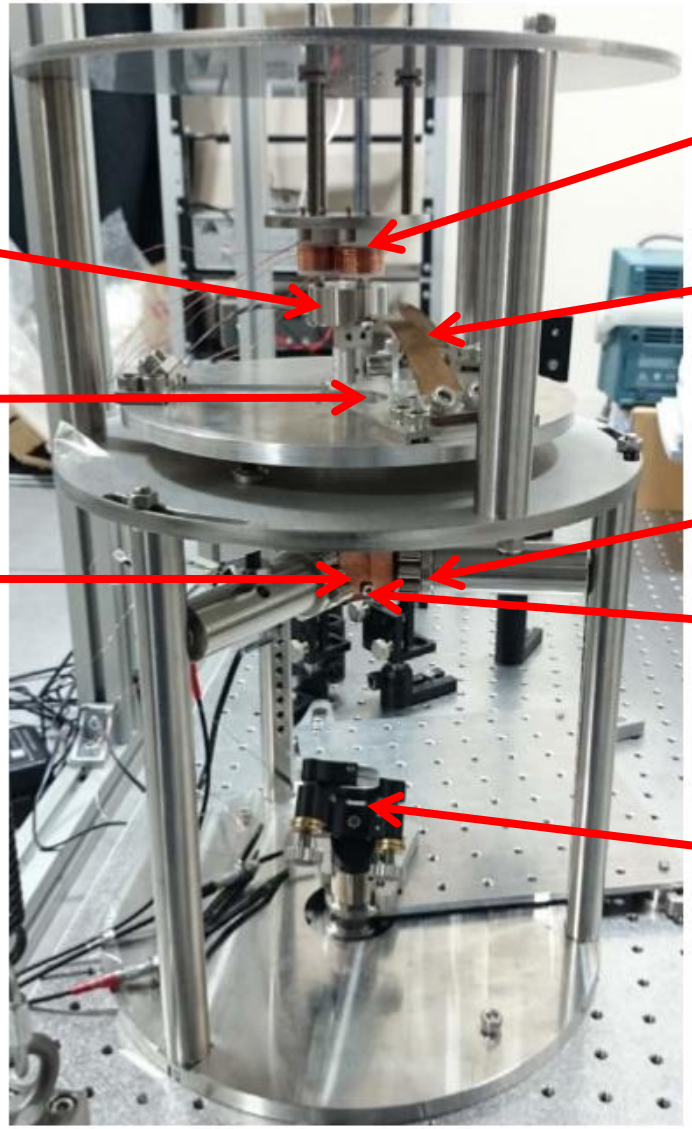
The general concept of this experiment



The prototype experiment



GAS unit



Coil
magnet
actuator

Keystone

Beryllium
GAS filters

Tungsten
wire

Damping
magnet

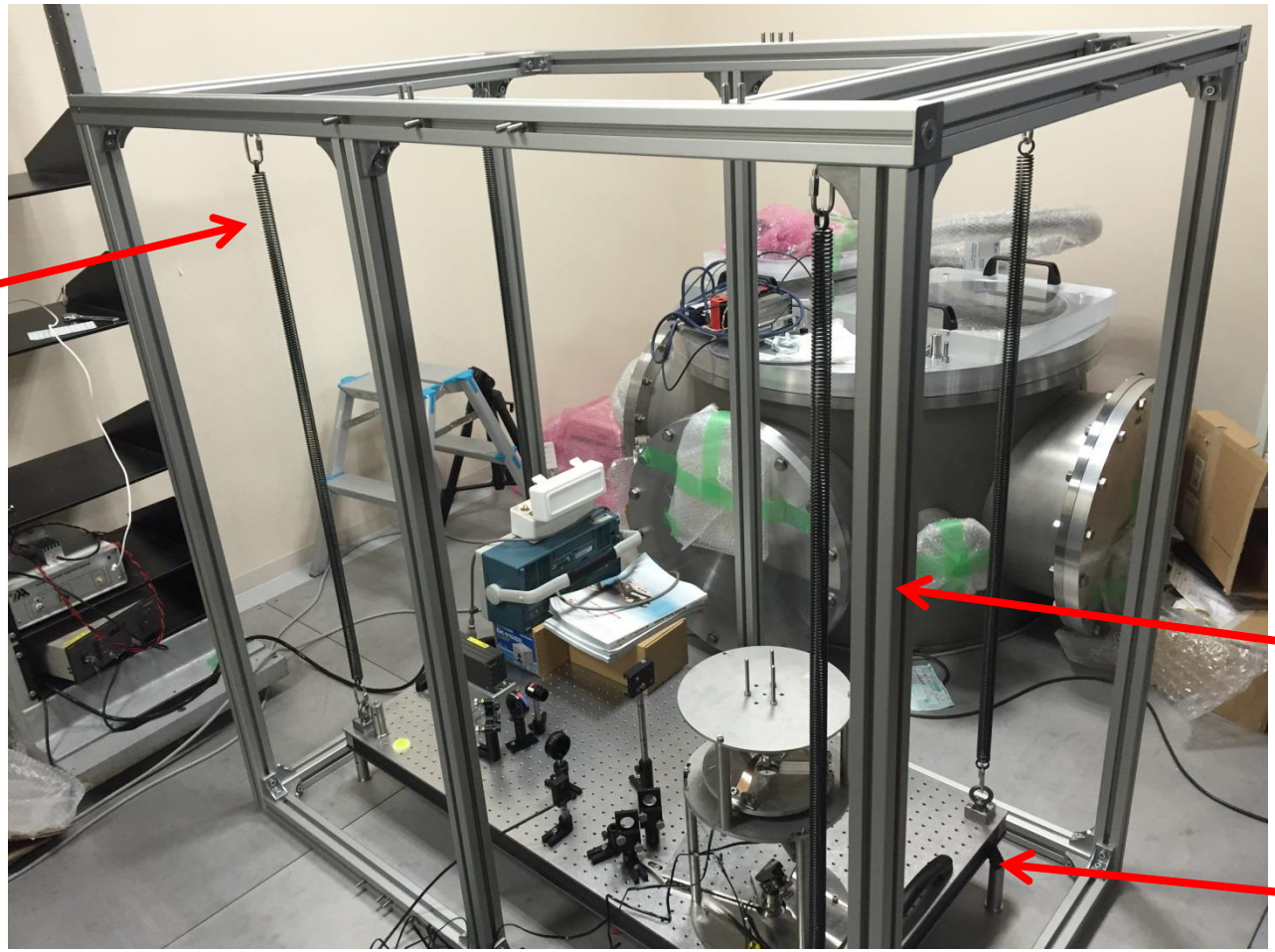
Mirror
holder

End
mirror

Folding
mirror

Vibration isolation system

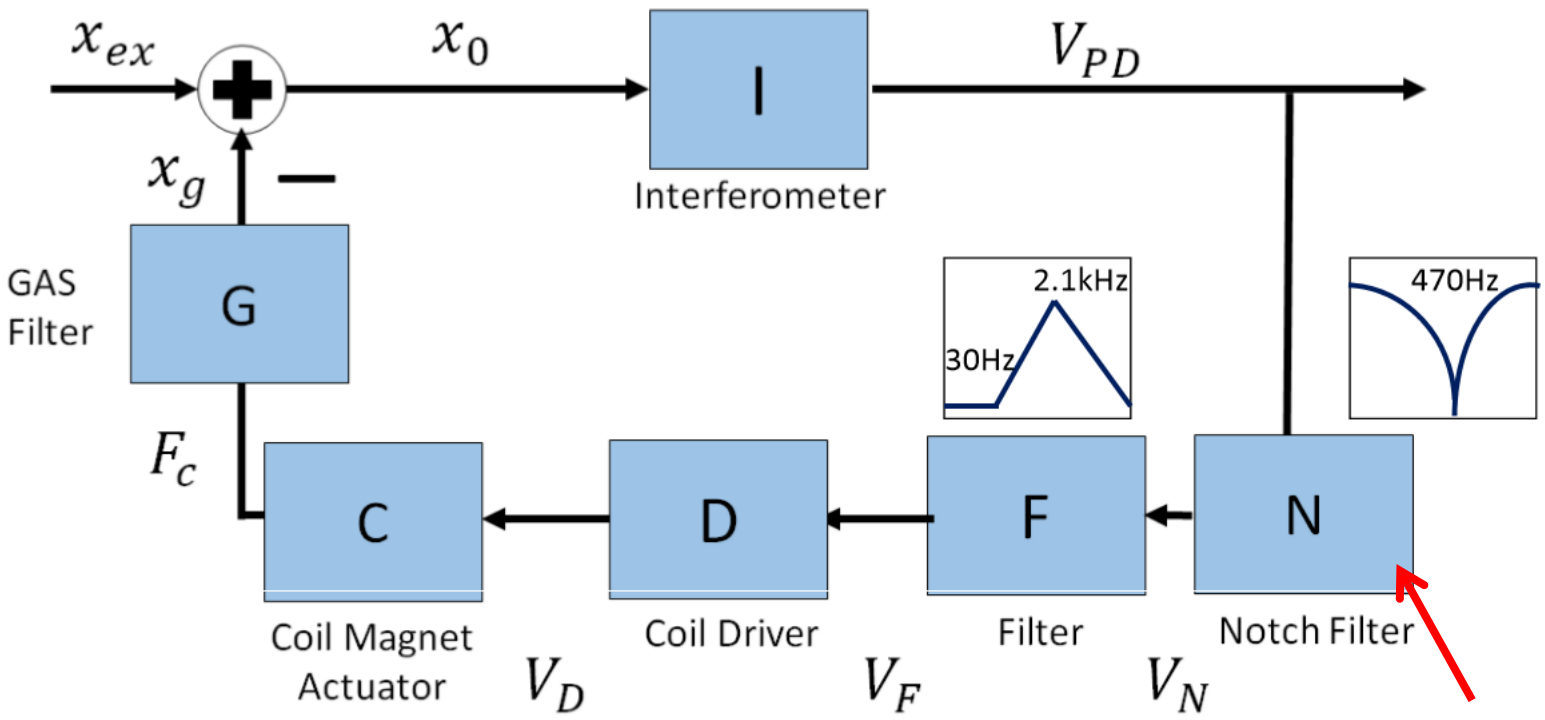
Spring Vibration Isolation (Resonant frequency ~0.8Hz)



Frame

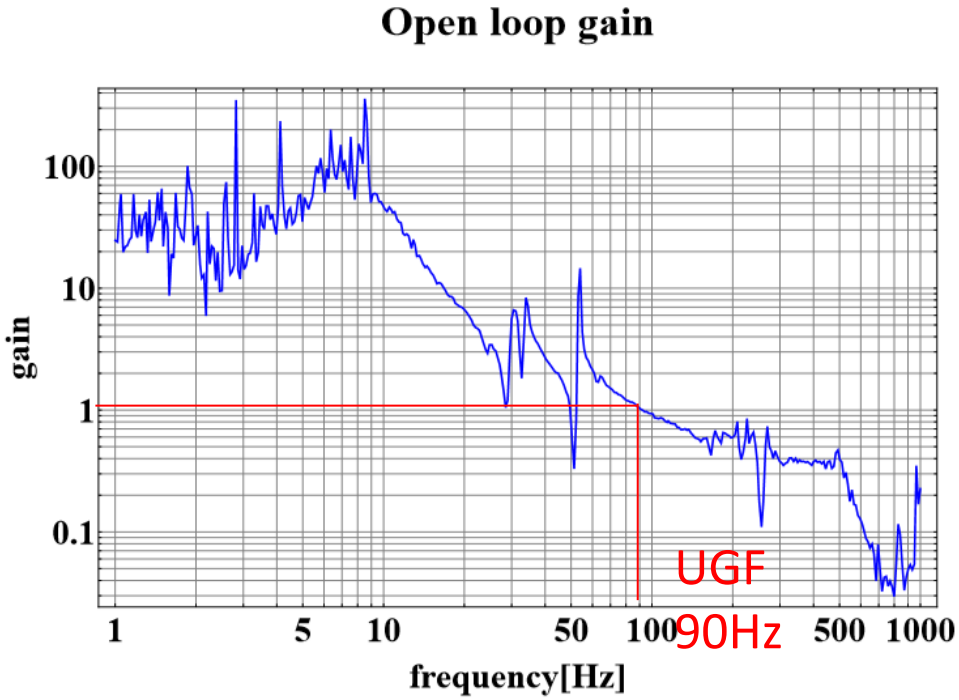
Rubber for damping

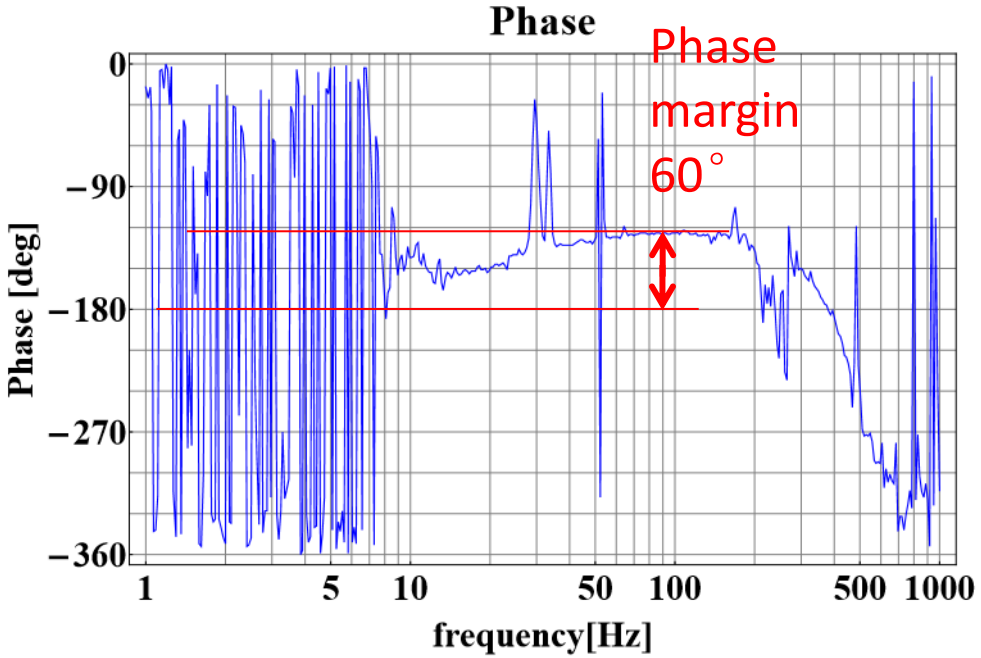
Control servo



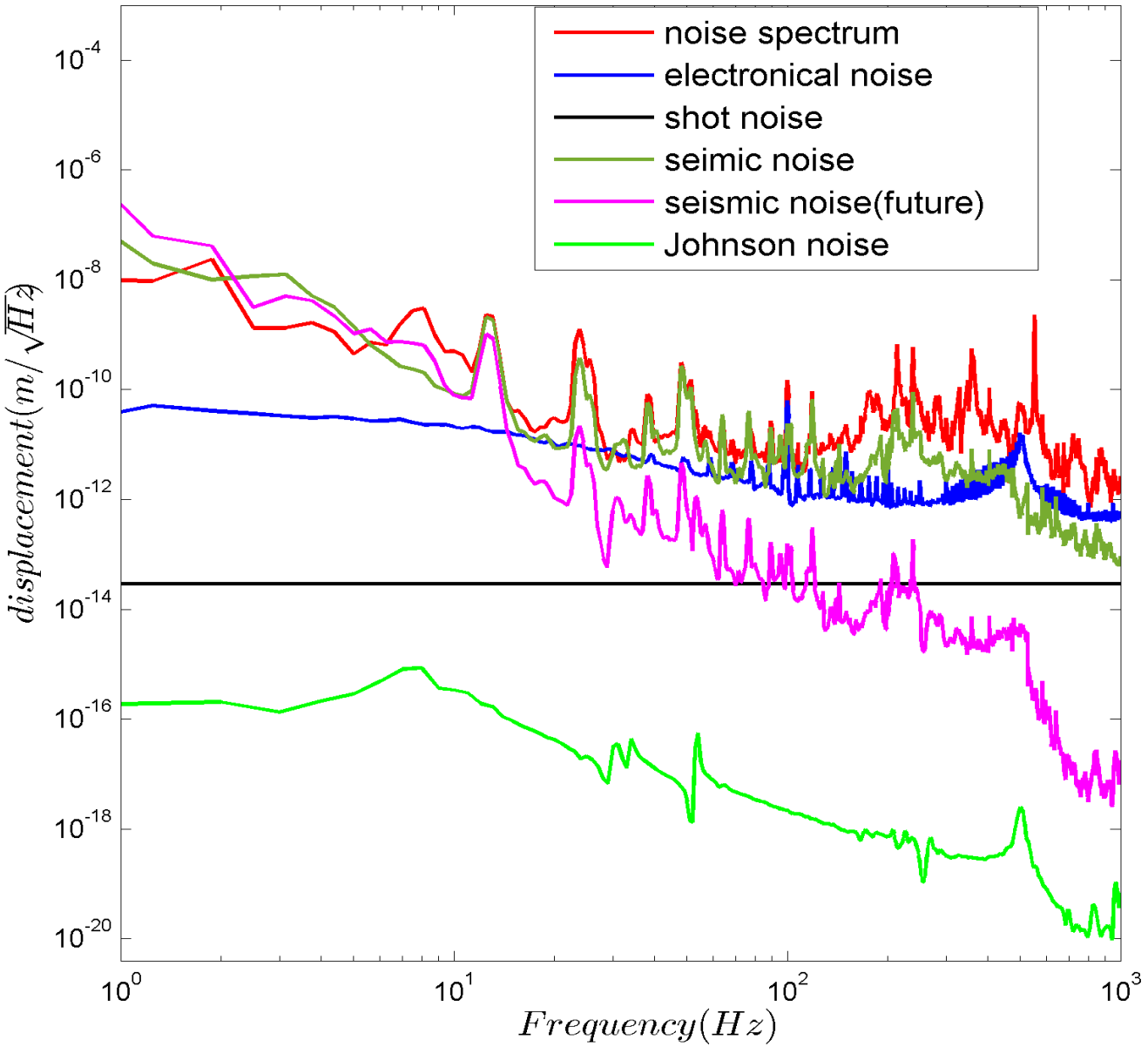
For spring mode of Tungsten wire

Open loop TF measurement



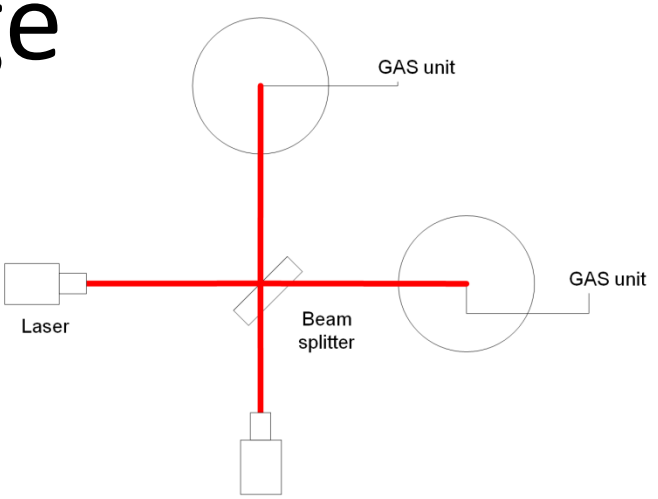


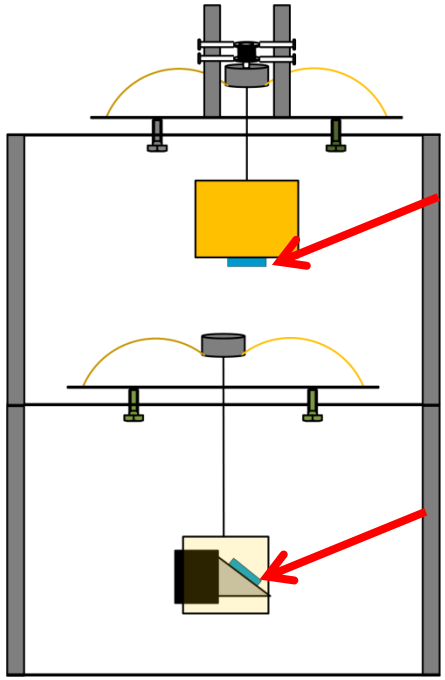
Noise spectrum



The next stage

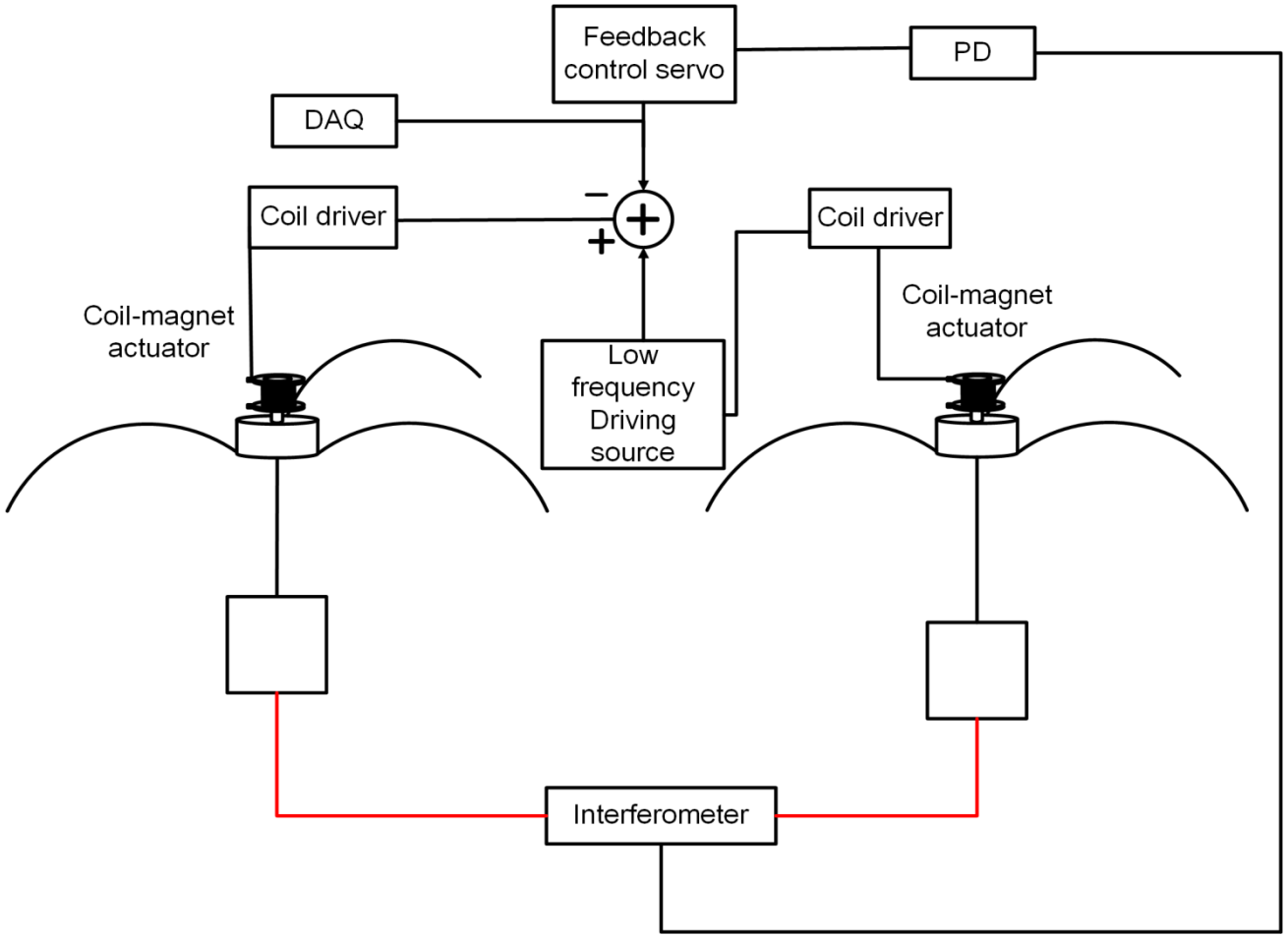
- To mount both ends with GAS unit.
- To suspend BS and folding mirror for vibration isolation.
- To do some improvements on the optics and circuits





The next stage-measurement method

- To implement DAQ, driving source, etc..
- Plan to take crackling noise data in air this summer !



Summary

- It is possible that crackling noise in the VIS would couple into KAGRA's readout.
- We use interferometric method and GAS filter to detect and measure crackling noise.
- We locked the interferometer with one GAS unit.
- We are going to make some updates and to take data in air this summer.
- Theoretical predictions for crackling noise and the evaluation to KAGRA are necessary for the future.