KAGRA and ET
~ Focus on the common points ~

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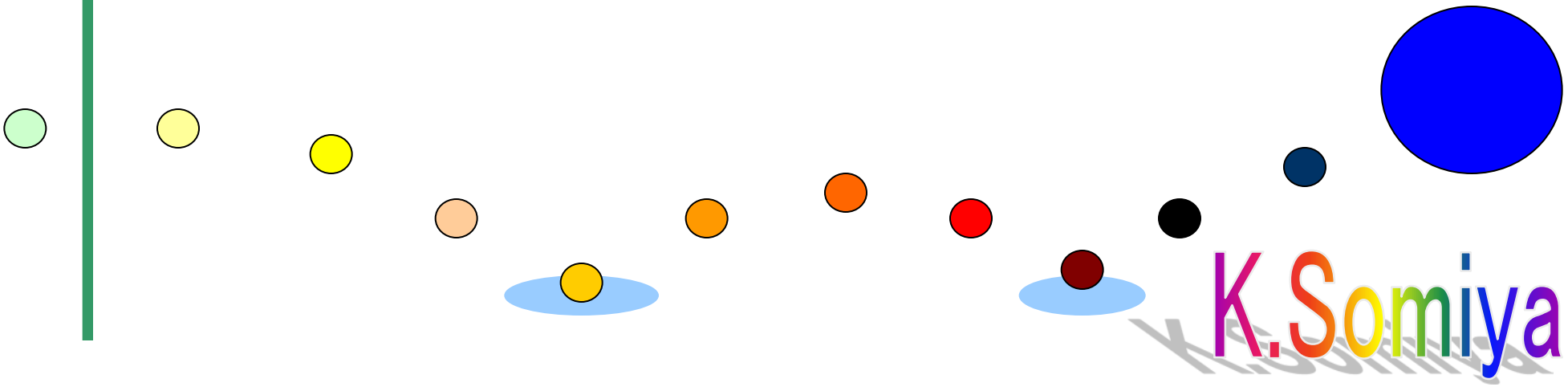


Contents

Common facts/issues

- underground
- optics
- cryogenic

Similar approach

- heat transfer via fiber
- 10~20K test masses

Different approach

- Xylophone
- Squeezing

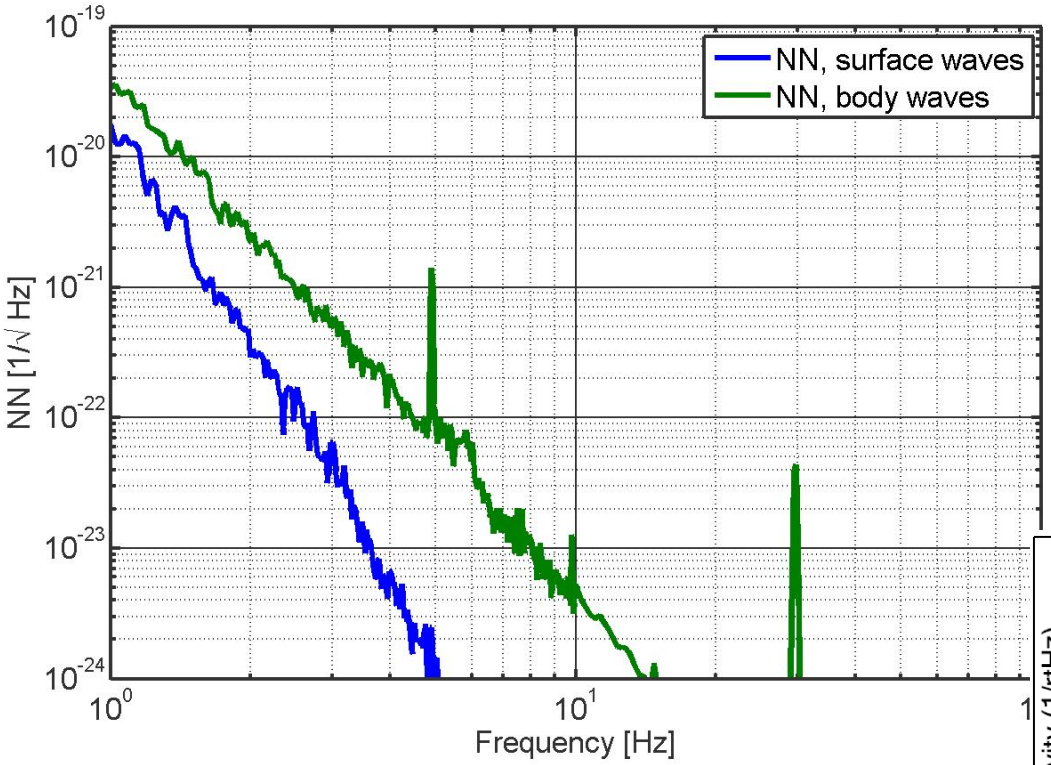
unknown/unsolved

At many points
ET and KAGRA
shall collaborate!!

Facts for underground facility

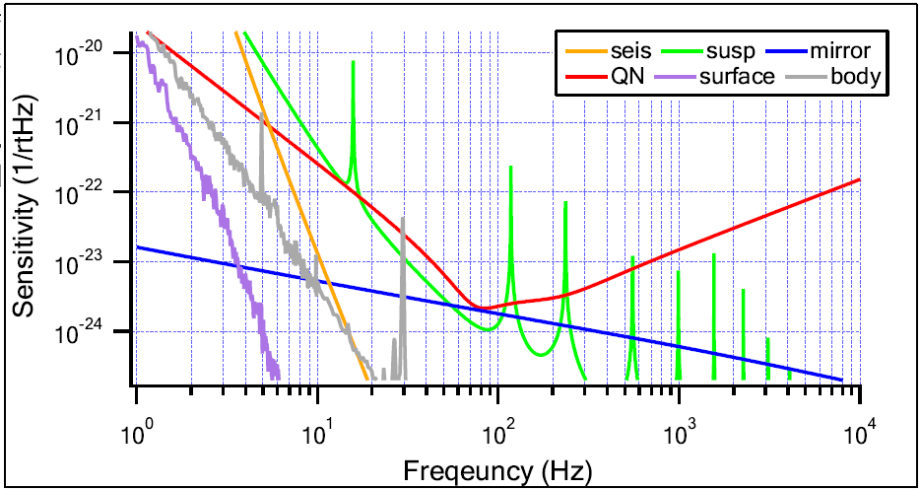
- Low gravity gradient noise
  - reduction of surface wave (not body wave)
- Cosmic ray filtering effect
  - Yamamoto et al, PRD 78, 022004 (2008)
- Water drainage issue
  - KAGRA is tilted by 1/300 for water drainage
- Usage of hard rocks
  - optical table legs are screwed in the rocks
  - possible reference for oplevs

Gravity gradient noise of KAGRA



Seismic motion measured by NIKHEF people (thanks!)

GGN calculation by J.Harms at Caltech (thanks!)



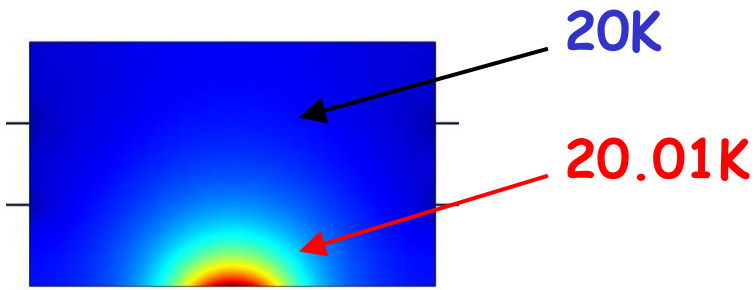
Surface waves are diluted in underground but bulk waves are not.

GGN cancellation may be needed for ET but it's fine for KAGRA

-> Hennes and Miyoki's talks today

Facts for optics

- Decent power in the arm cavity
  - P_{KAGRA}=200~400kW (1/4~1/2 of aLIGO)
  - Xylophone for ET (P_{ETLF}=18kW, P_{ETHF}=3MW)
- Thermal lensing
  - No lensing for KAGRA
  - An issue for ET-HF

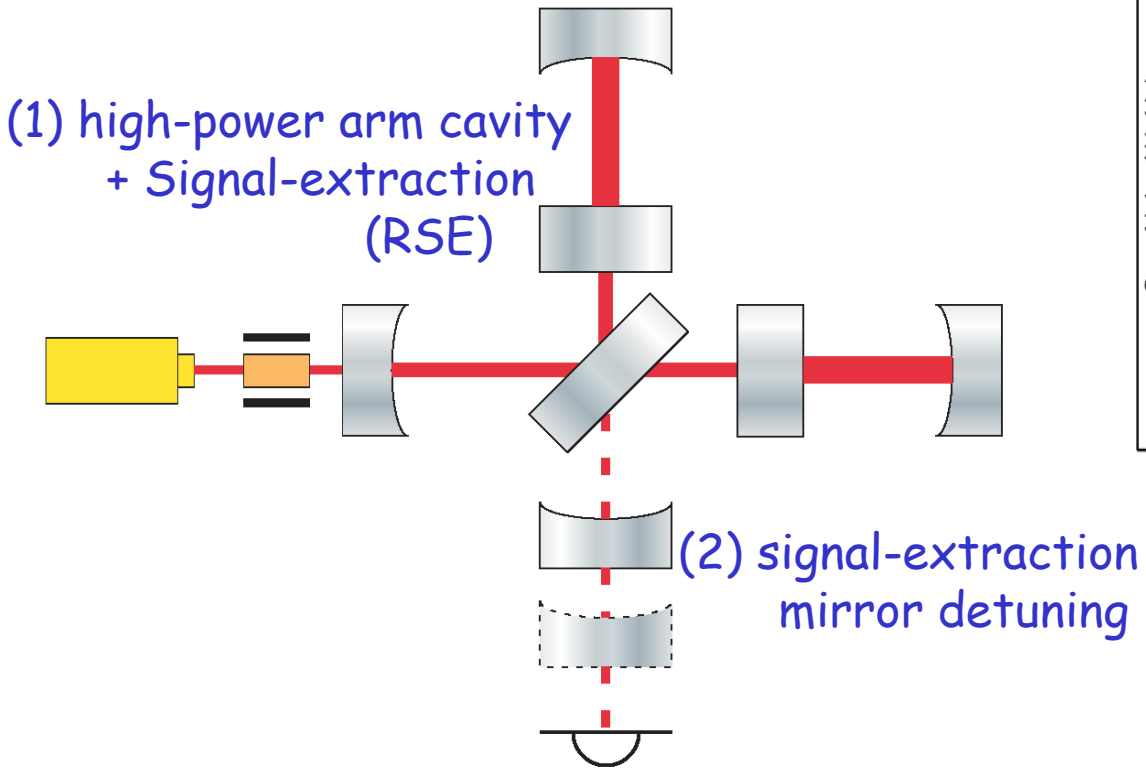


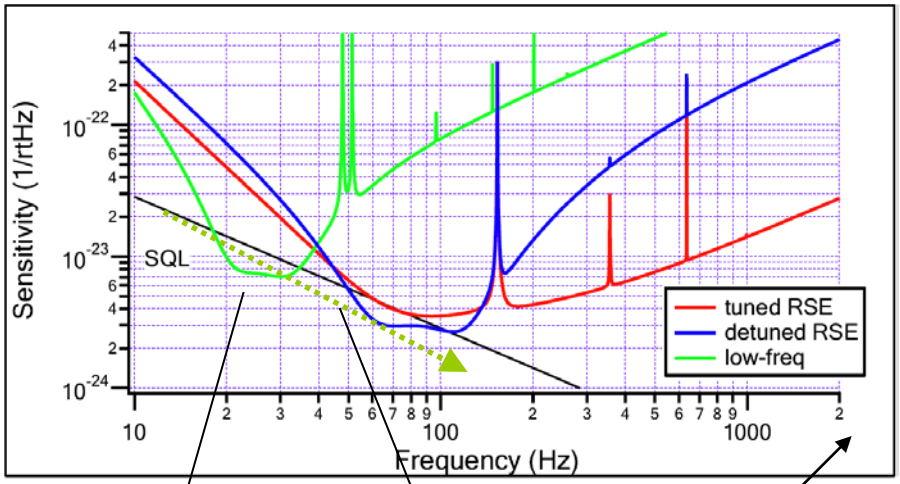
Temperature profile of KAGRA ITM
(courtesy calculation by M.Arain)

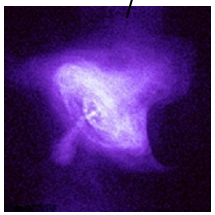
- Parametric instability
  - No instability in KAGRA
  - An issue for ET-HF

-> Shibata's talk tomorrow

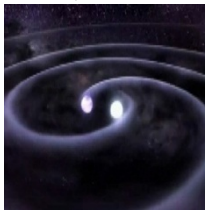
KAGRA's topology







Pulsars
(Vela at 22Hz)



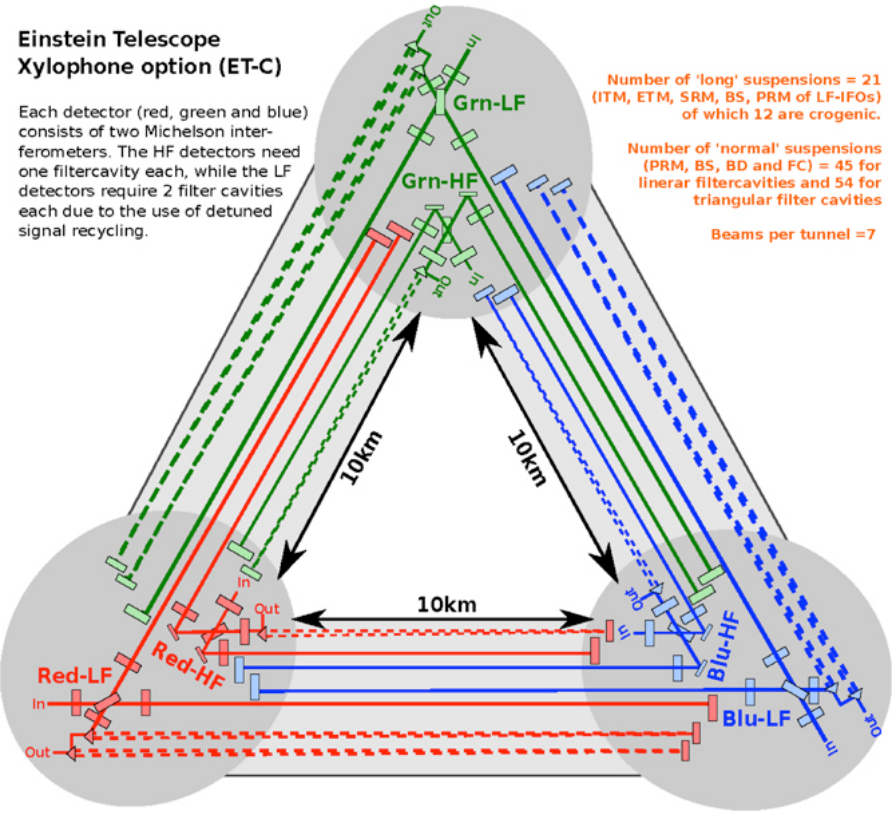
BNS inspiral

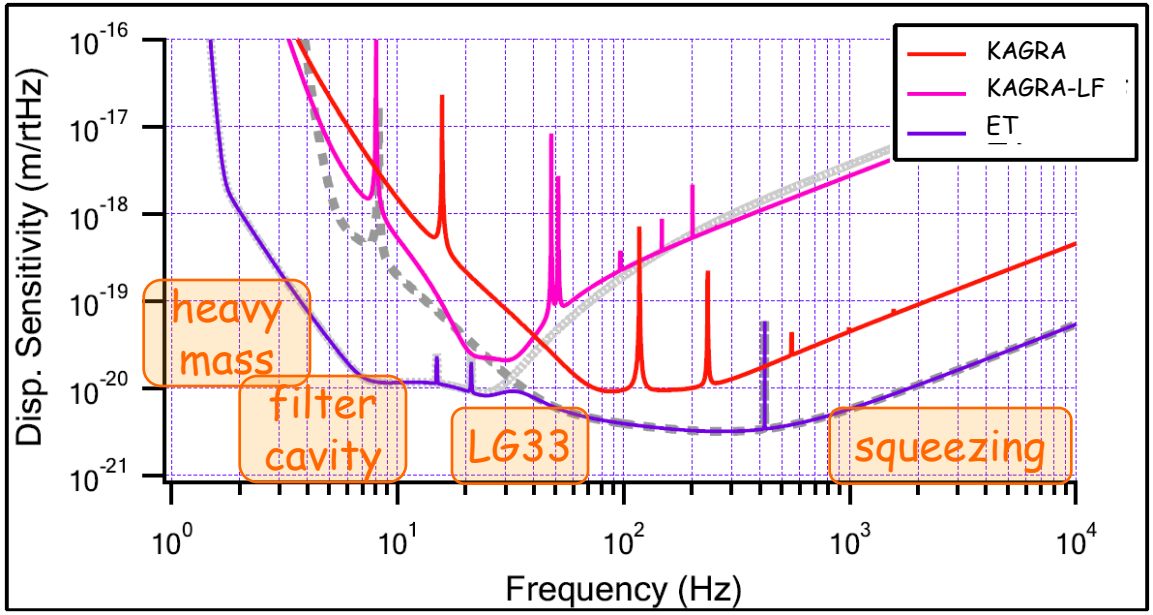
Supernovae

- RSE is the best for operation with low incident power
- We could improve the sensitivity in a narrow band

(-> turns out to be not good, and we chose decent detuning for bKAGRA)

ET's topology





- 3x2 interferometer + 2 filters
- cryogenic LF + high-power HF

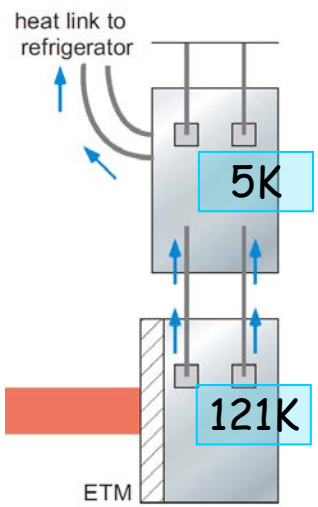
- Squeezing helps to avoid too much power in ET-HF
- Xylophone removes the high-power issue in ET-LF

(We discussed a Xylophone with KAGRA and AdVirgo but it's not as good.)

High-power issues for ET-HF

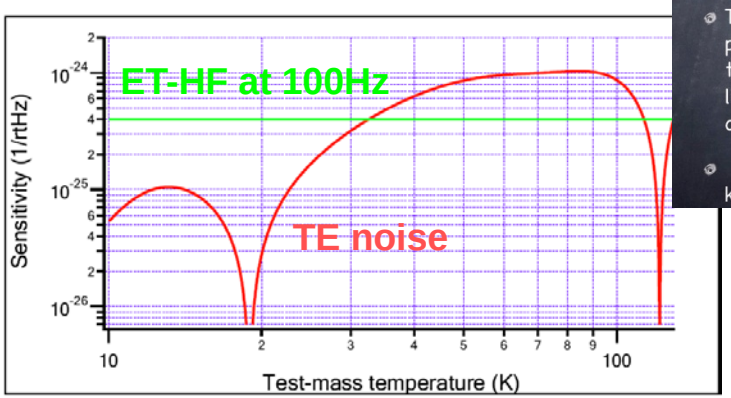
4-times higher power than aLIGO
-> thermal lensing? parametric instability?

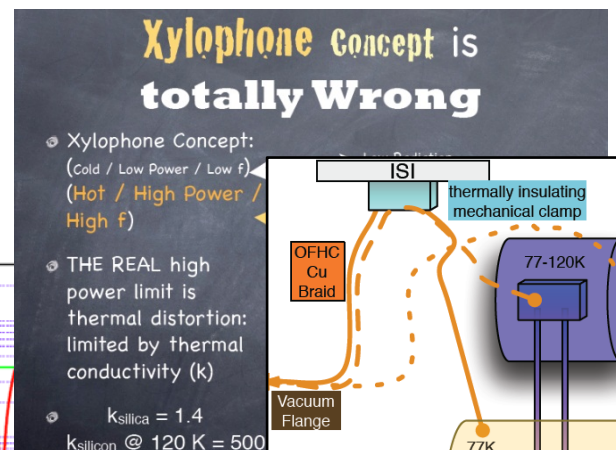
One solution would a 120K Silicon



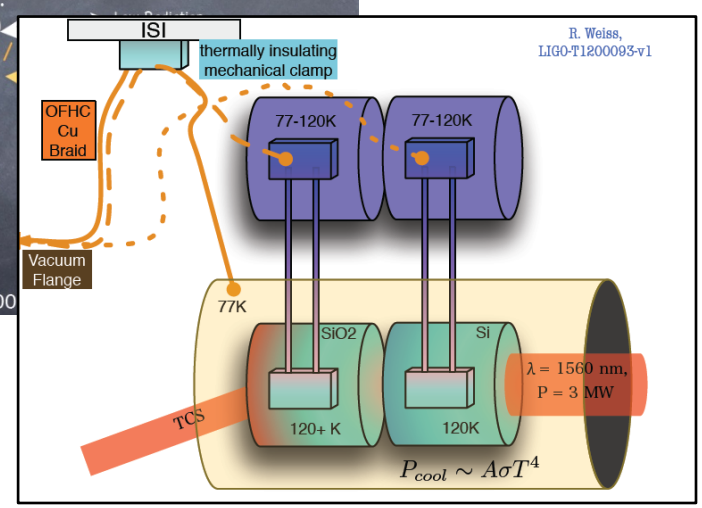
120K ET-HF
LIGO-G1000567

* Thermal expansion of Silicon is zero at 120K.





LIGO3 by Rana
LIGO-G1200573



Facts for cryogenics (1/2)

- **Mirror absorption**
  - 30~60ppm/cm for Sapphire
  - expected to be very low for Silicon

    -> WP2 talks tomorrow
- **Coating mechanical loss**
  - 3e-4 for SiO_2, 5e-4 for Ta_2O_5 (KAGRA)

    cf. 5e-5/2e-4 is available at 300K

    -> WP2 talks tomorrow
- **Cryogenic suspension**
  - Thick fibers for KAGRA
  - How to suspend mirrors?

    -> WP1 talks tomorrow

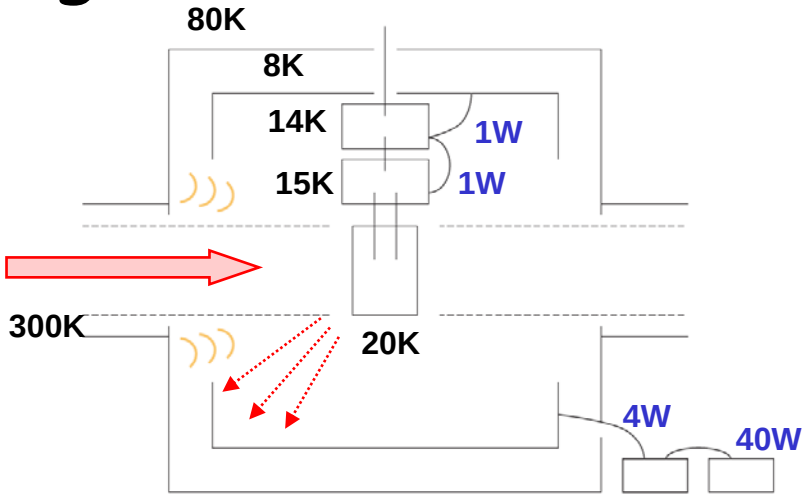
Facts for cryogenics (2/2)

- Initial cooling time
  - Radiation + heat link for KAGRA
  - GAS cooling plans for ET
  - Duty factor loss (2 month loss/maintenance)

    -> Sakakibara and Ricci's talk today

- Heat from scattered light

  -> Yamamoto's talk tomorrow



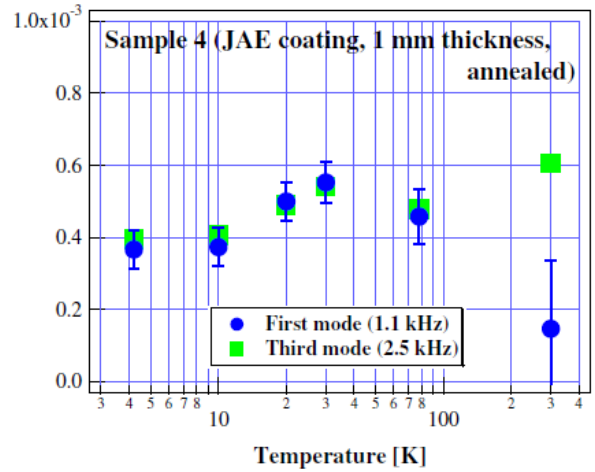
Sapphire vs Silicon

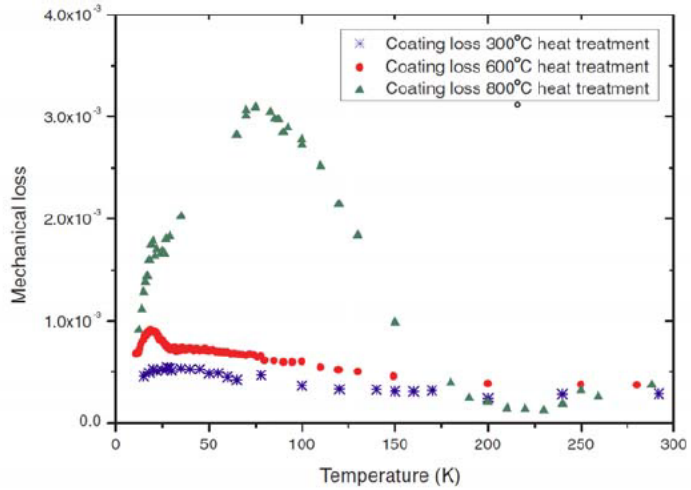
	Sapphire	Silicon	difference
Max size available	23~30kg	100+kg	susp TN, RP noise
Subst. Absorption	30+ppm/cm	0 (??)	shot noise
Laser wavelength	1064nm	1550nm	~1.2 in coat TN
			~1.2 in shot noise
Young's modulus	400GPa	132GPa	~1.4 in coat TN
			~2.3 in elast. mode density for PI
Fiber bonding	weak	strong	??
Coating material	Ta_2O_5-SiO_2	Silicon-SiO_2	~2.5+ in coat TN

Silicon seems to solve most of the issues in KAGRA but there are still many unknowns to be studied.

Mechanical loss of coatings

	Tantala	Silica	Average
290K	2e-4	5e-5	1.3e-4
20K, Tokyo	--	--	5.0e-4
20K, 600C, Glasgow	1e-3	5e-4	7.8e-4
20K, 600C, Glasgow (Ti-doped Tantala)	8e-4	5e-4	6.7e-4
20K, 300C, Glasgow	6e-4	--	--
20K. 300C, Glasgow (Ti-doped Tantala)	--	--	--
KAGRA goal	5e-4	3e-4	4.1e-4





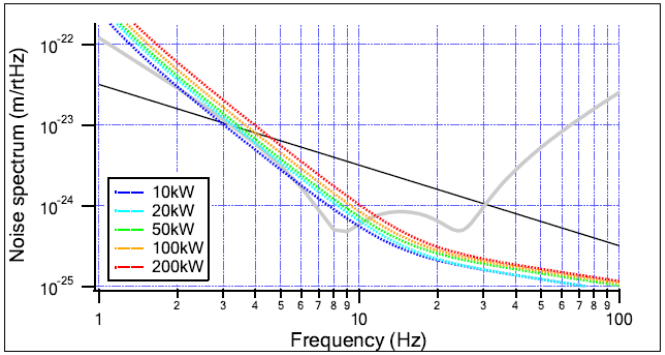
(top) Measurement in Tokyo
(bot) Measurement in Glasgow

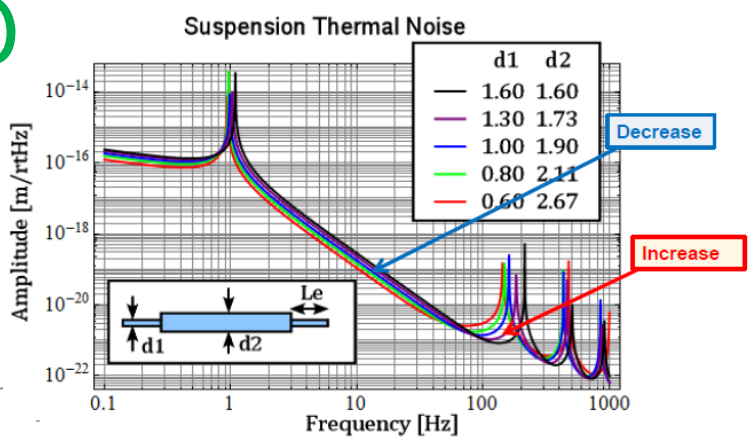
Slight difference between measurement results in Tokyo and in Glasgow.

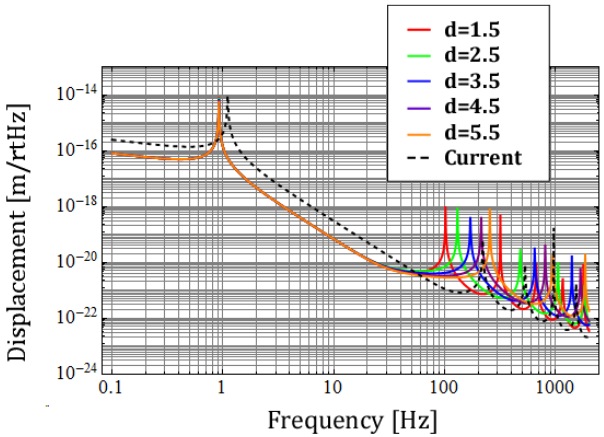
Annealing temperature might be the reason of the difference…?

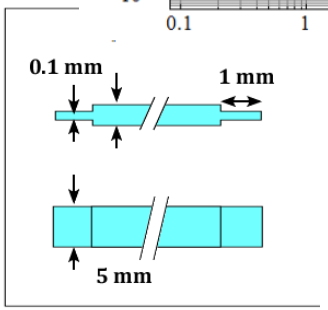
Suspension study

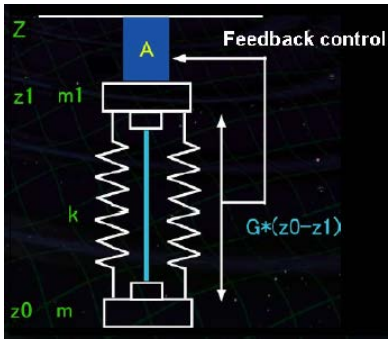
- Cryogenic ribbon suspension (Kokeyama)
- Vertical Suspension point IFO (Ando)
- Non-uniform fiber (Sekiguchi, Johnson)
- Composite suspension [non-uniform ribbon] (DeSalvo, Sekiguchi)











What can we do in ELiTES?

- ✓ Knowledge exchange of underground infrastructure
- ✓ Mechanical/optical property study of our materials
- ✓ Mechanism of coating loss at low temperatures
- ✓ Exploration of better suspensions
- ✓ Exchange of young people
- ✓ Inspiring each other

KAGRA

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