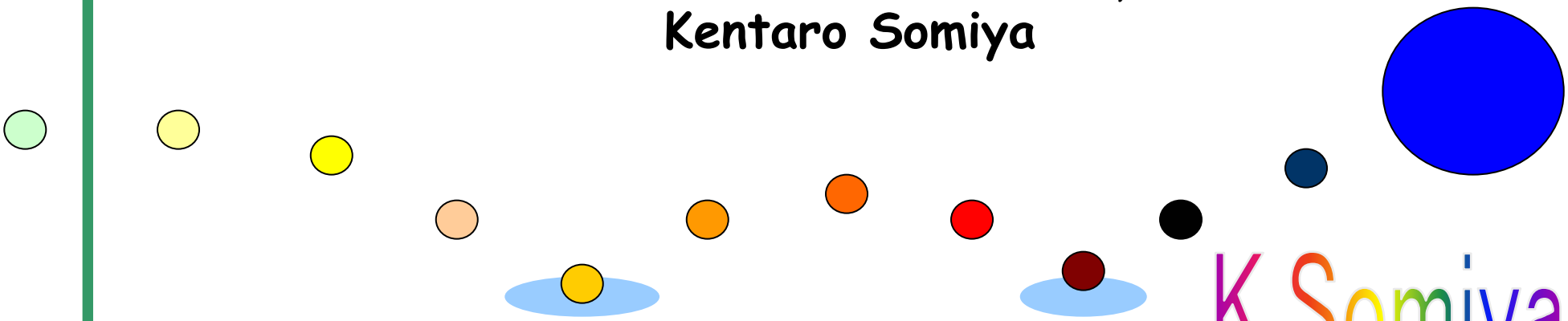
Alternative Technologies?

The 3rd ET General Meeting @ Budapest

Nov. 2010

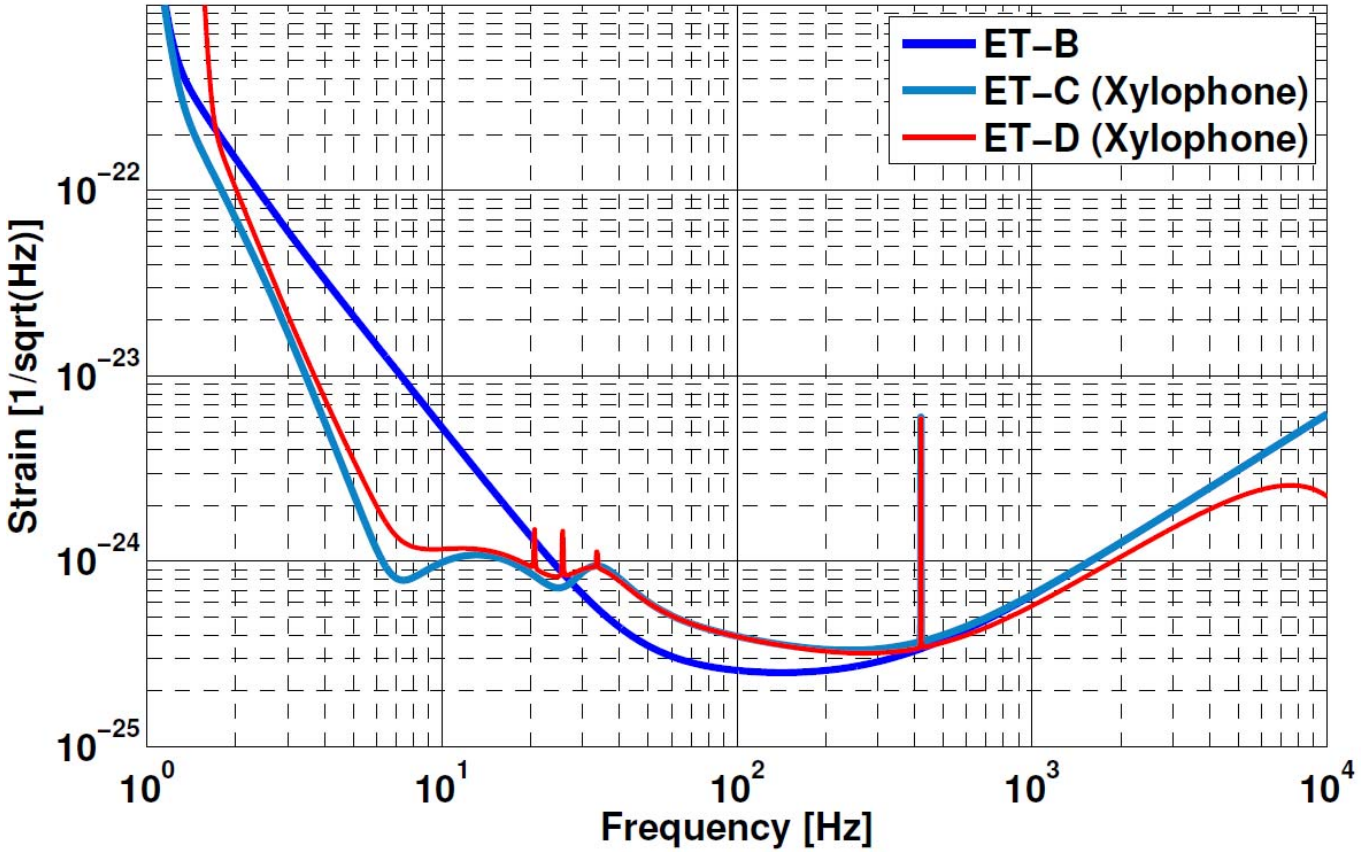
Waseda Inst of Advanced Study

Kentaro Somiya



ET-D sensitivity

by S.Hild *et al.*



ET-LF
- 2m suspension (d=5mm)
- 10K 211kg silicon
- 18kW DRSE
- FD-SQ + FD-HD

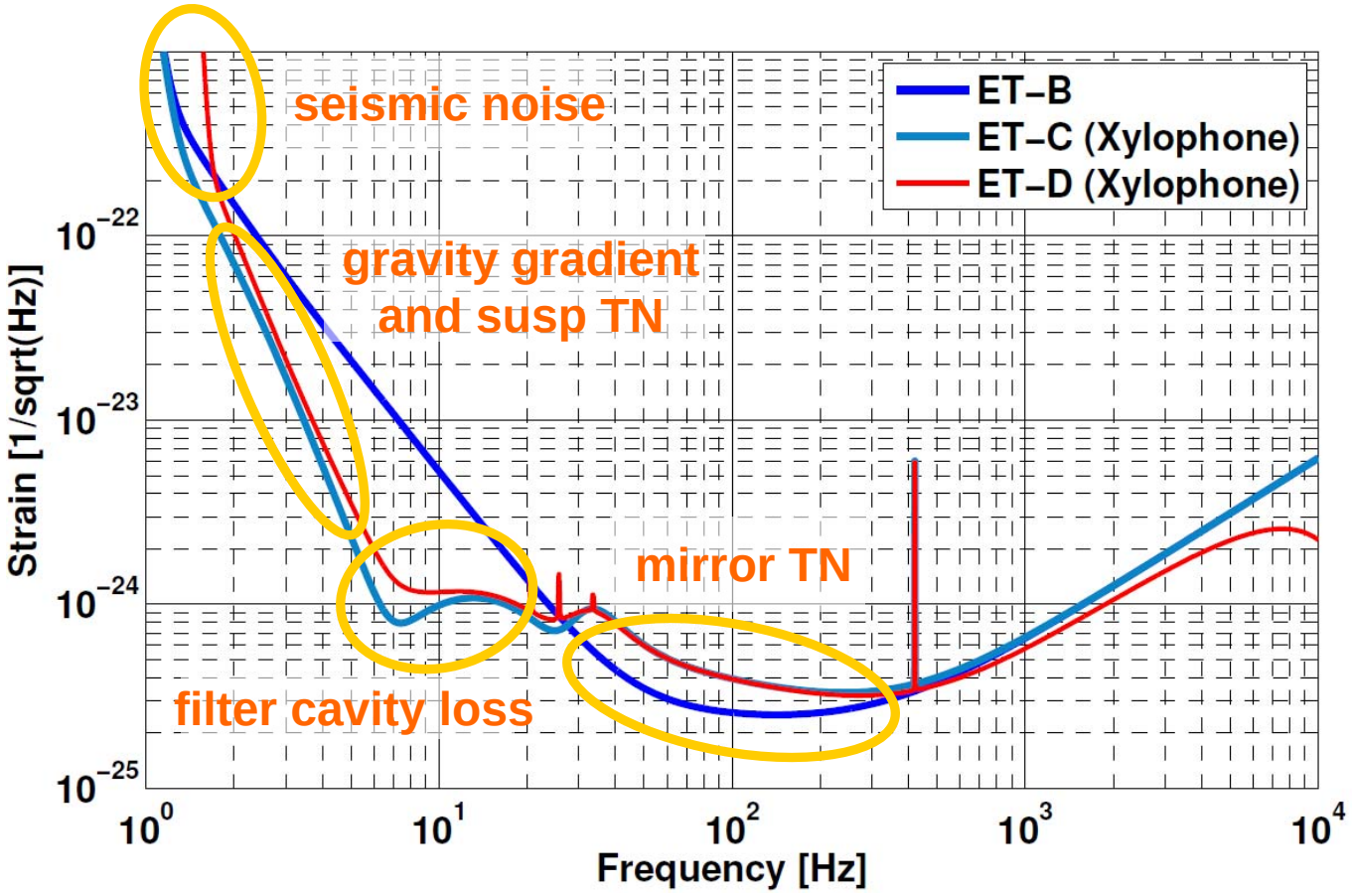
ET-HF
- 290K 200kg silica
- 3MW LG33 RSE
- FD-SQ + FD-HD

ET-D = ET-C Xylophone curve + susp TN + F-cav losses

Quite realistic sensitivity

ET-D sensitivity

by S.Hild *et al.*



available?

ET-LF
- 2m suspension (d=5mm)
- 10K 211kg silicon
- 18kW DRSE
- FD-SQ + FD-HD

ET-HF
- 290K 200kg silica
- 3MW L033 RSE
- FD-SQ + FD-HD

heat problem?

ET-D = ET-C Xylophone curve + susp TN + F-cav losses

Quite realistic sensitivity

List of more advanced techniques

- (Gravity-gradient subtraction) [Harms PRD 09] See Talk by G.Cella
- Suspension-point interferometer
- K-etalon and coating-less mirrors
- (EIT filter) [Mikhailov PRA 06]
- (Speed-meter) [Chen GRG 10] See Talk by H.Mueller-Ebhardt
- (Ponderomotive amplifier) [LIGO-G1000568]
- 120K ET-HF
- Kamaboko mirror

Grav-grad noise

Seismic noise

Suspension TN

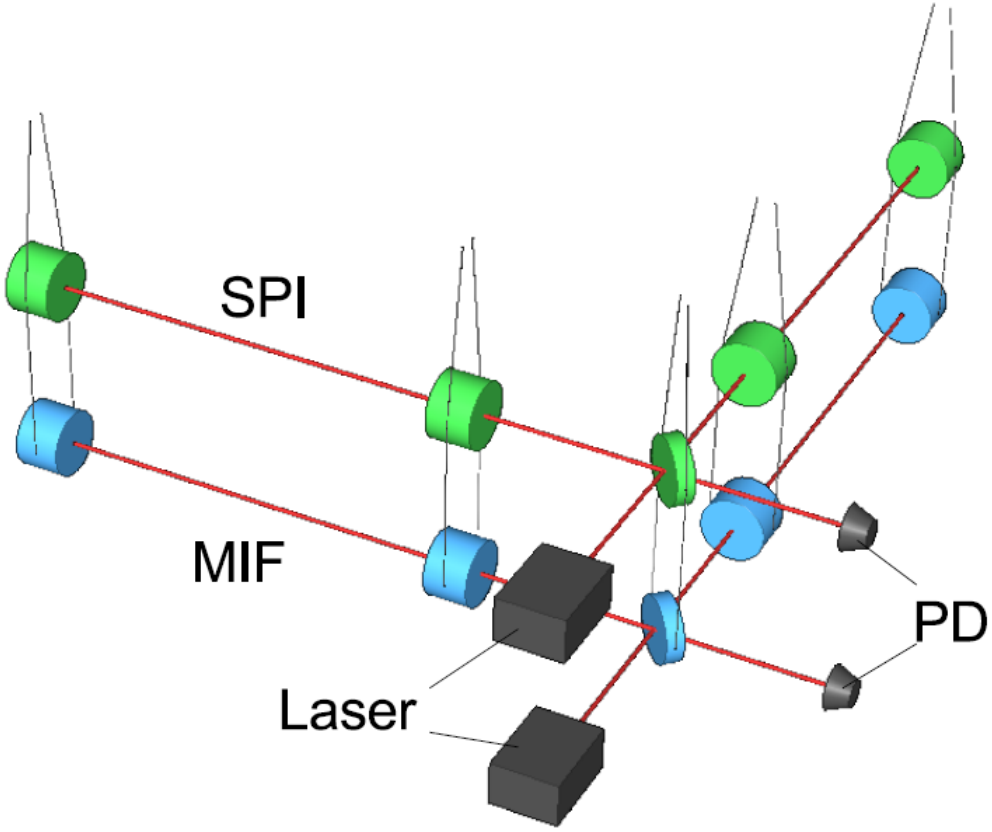
Mirror TN

F-cav losses

High-power issue

Silicon-mirror issue

Suspension-point interferometer

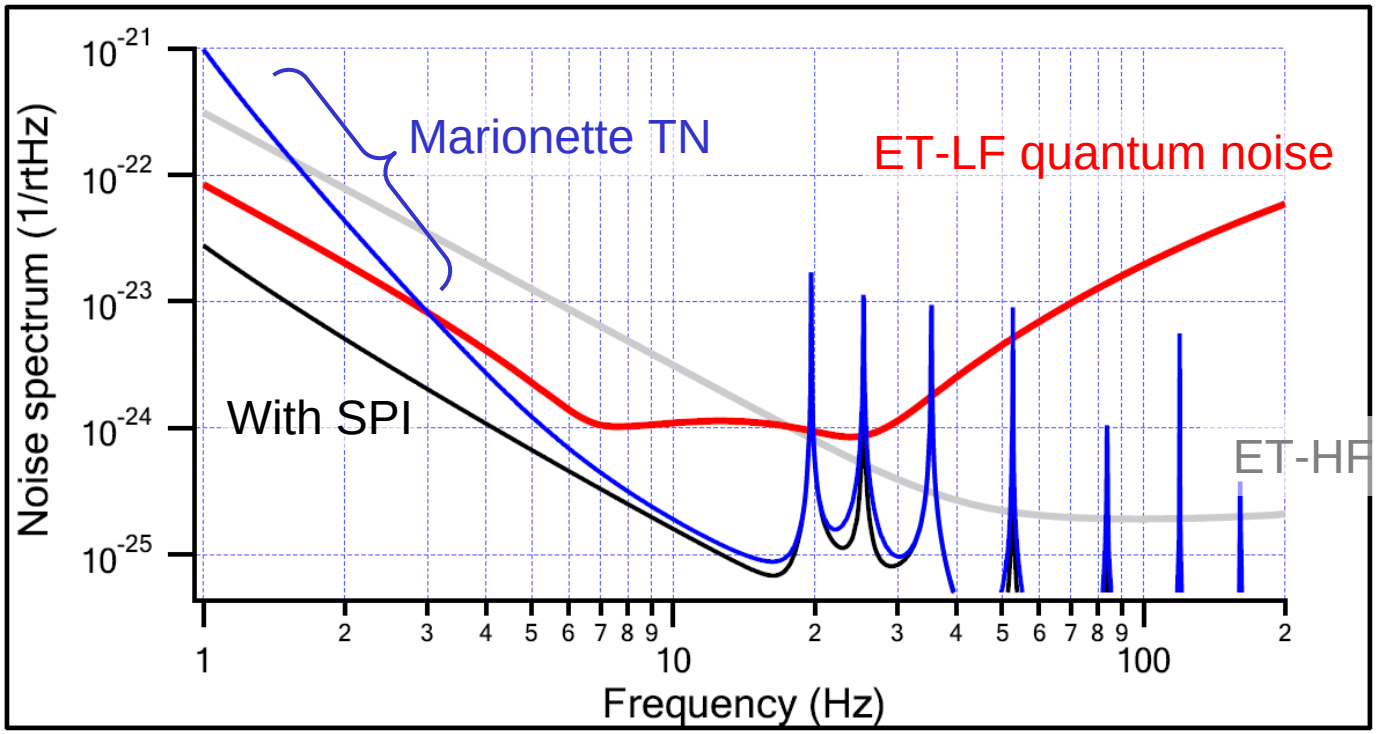


R.Drever (1987)
Y.Aso (2004)

- Reduce seismic noise and RMS motion
- Reduce mixture of Marionette TN and heat-link vibration
- Planned for LCGT but given up for the high cost

TN reduction with SPI

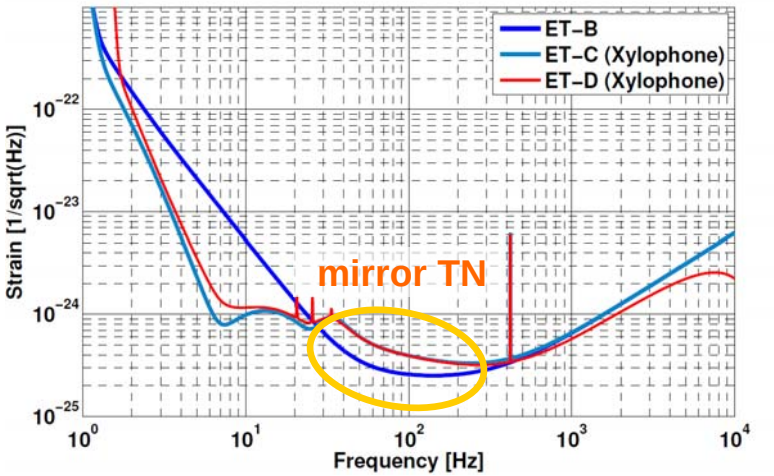
Susp TN calculated with the code by F.Piergiovanni, M.Punturo and P.Puppo (2009)
Quantum noise calculated by **A**.Thuering and H.Mueller-Ebhardt (2010)



SPI can improve the sensitivity at f<~30Hz.

Some suspension parameters are quite challenging.
(ex. Structure loss of 1e-9, Vertical-Horizontal coupling of 1e-3)
→ Ribbon suspension should be considered.

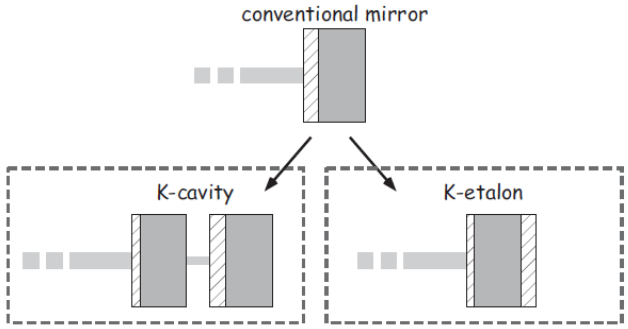
Mirror TN reduction in room temperature

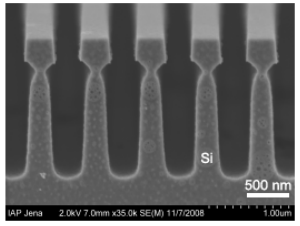


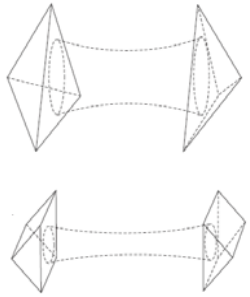
There are 4 ways to reduce mirror TN:
(i) Increase effective beam radius
(ii) Decrease the number of coatings
(iii) Increase Q
(iv) Decrease temperature

A number of proposals to decrease coating layers

- **Khalili cavity/etalon**
  ~ Control issue and heat issue
- **Monolayer grating**
  ~ Noise behavior is being investigated
- **Corner reflector**
  ~ Heat issue and TR noise
- **Blue laser IFO**
  ~ Scattering and absorption issue
  ~ Shot noise improvement







Heat issue in ET-HF

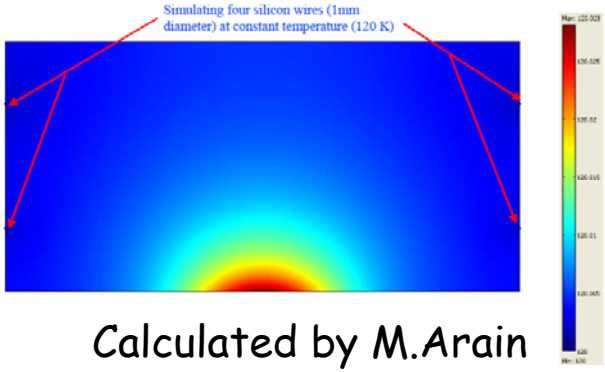
Problem

3MW in each arm → 1-2W heat absorption
→ 290K becomes 293K+ at the center
→ Thermal lensing
→ TCS noise

Solution = 120K ET-HF

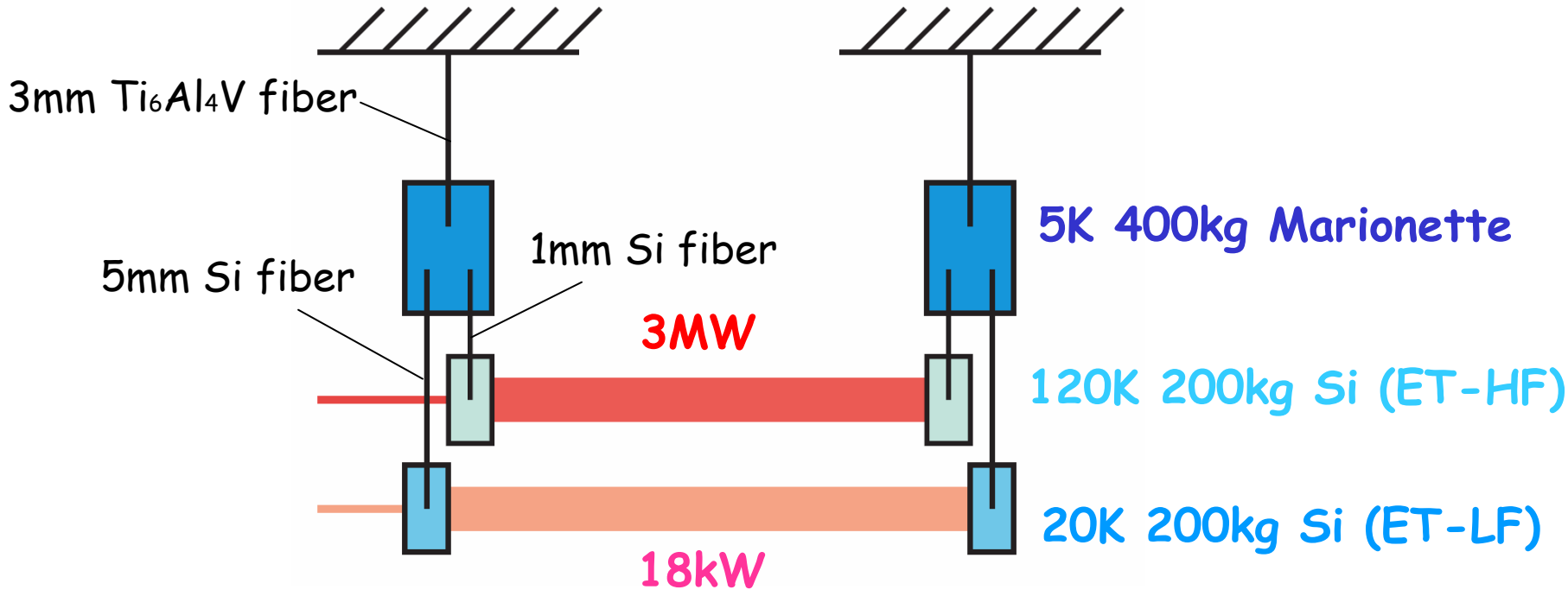
We can cool down ET-HF as well!

- Thermal conductivity is high at 120K
- Thermoelastic noise is zero at 120K
- Thermal lensing is almost zero
- Thermal noise is reduced by ~55%



Calculated by M.Arain

20K-120K Xylophone with SPI

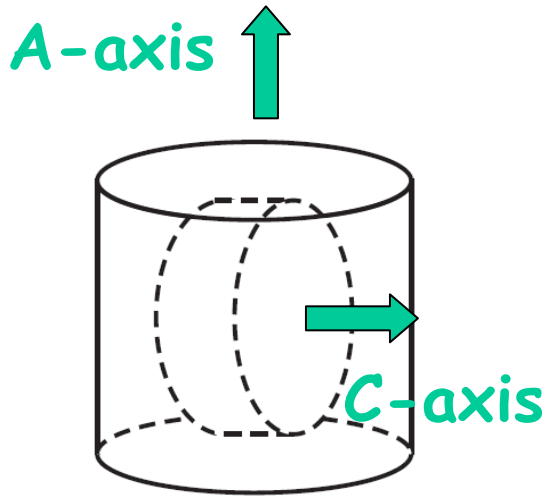


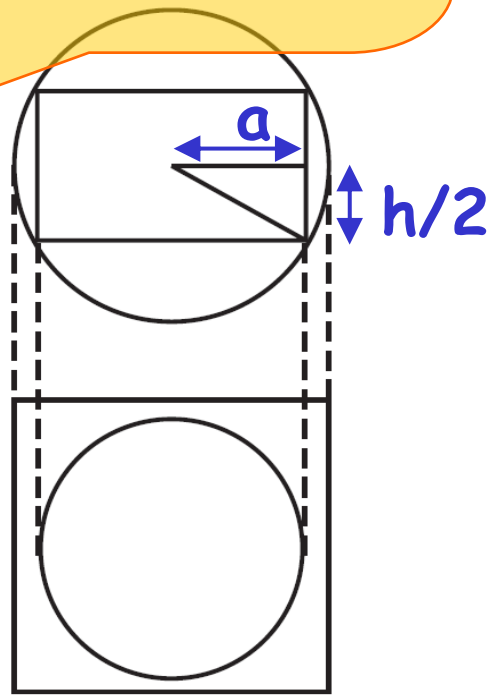
- SPI reduces seismic noise and susp TN on Marionette
- Alignment control is made on Marionette and 120K mass
- Suspension TN and mirror TE noise are small
- Setup is simpler

Larger mirror

Can we make a 200kg silicon mirror?
Can we make a bigger one?

Sorry,
This was the case for Sapphire
(pointed out at the meeting)





A-axis cylinder is made in Czochralski process.
C-axis cylinder is needed for GWD mirrors.

Maybe we can make R=30cm a-axis cylinder?

$R^2=a^2+(h/2)^2$

h<<a makes thermal noise large

a=26.8cm → m=140kg (a=h/2)
a=24.5cm → m=150kg (max)

Kamaboko mirror

New idea being considered for LCGT

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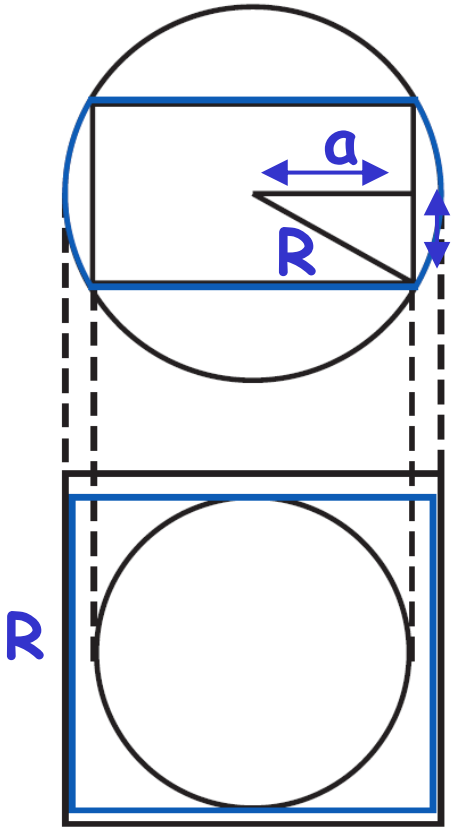
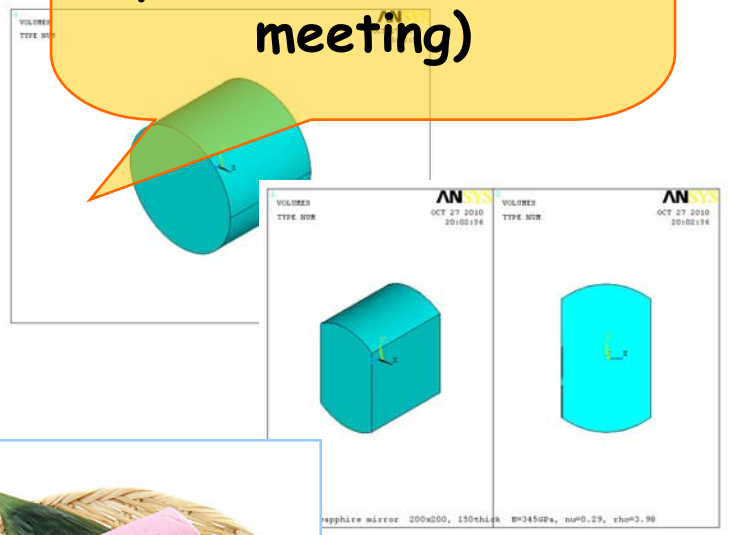


$M=\rho(ah/2+2R^2\tan^{-1}[h/2a])R$

$a=24.5\text{cm} \rightarrow m=211\text{kg}$



One way to realize heavy crystallized c-axis mass.
There might be a better shape.

Summary

- Susp TN at f<10 can be improved with SPI
- Multiple ways to improve mirror TN have been proposed
- 120K ET-HF improves mirror TN w/o problems of susp TN
- 120K ET-HF helps heat issues
- Kamaboko mirror

- Seismic noise could be suppressed a bit more with SPI
- Gravity gradient noise can be hopefully lowered
- EIT filter could be useful for the filter cavity
- Speedmeter realizes sub-SQL w/o filter cavities
- Ponderomotive/NLC amplifier is strong against losses