Bandwidth special WG report

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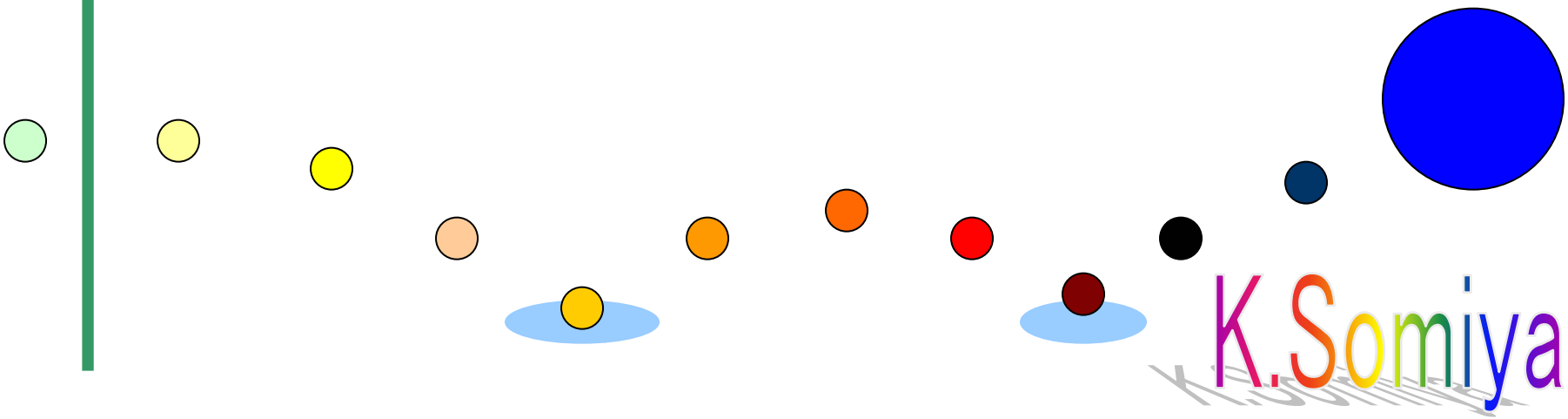
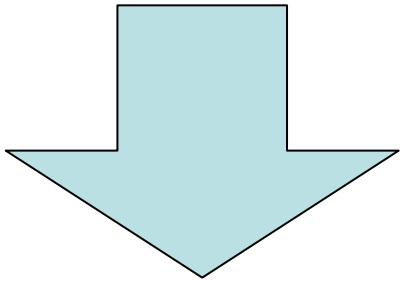


Background

- We'll buy Sapphire mirrors with the LRIP money
- diameter: 25cm → 22cm (30kg → 22.8kg)
- substrate absorption: 20ppm/cm → 50-70ppm/cm

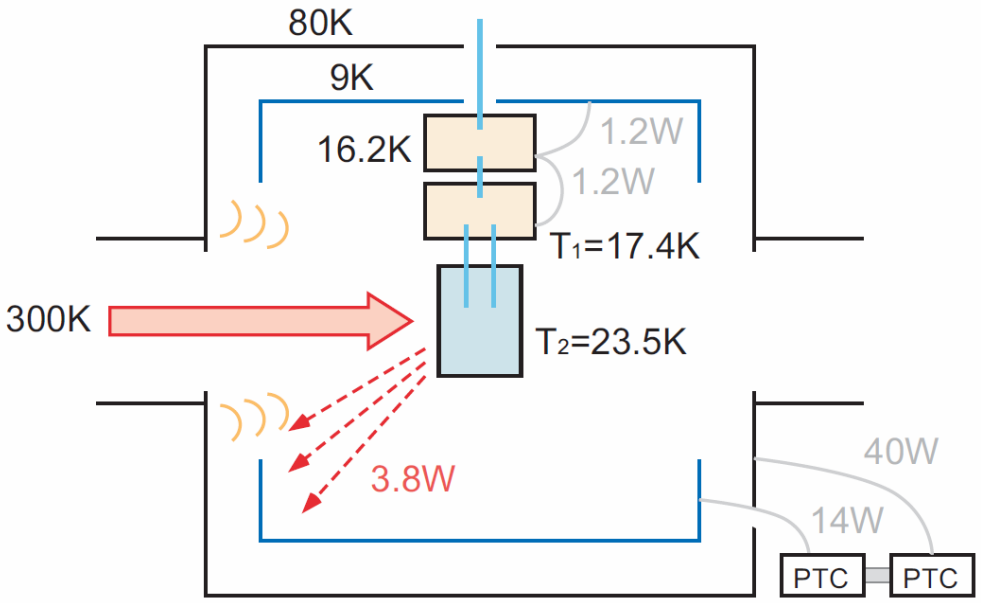


moreover…
coating abs: 0.5ppm -> 1.0ppm?
inner shield: 8K -> 9~11K?

The mirror temperature will increase
⇒ less power? thicker fibers? higher/lower finesse?

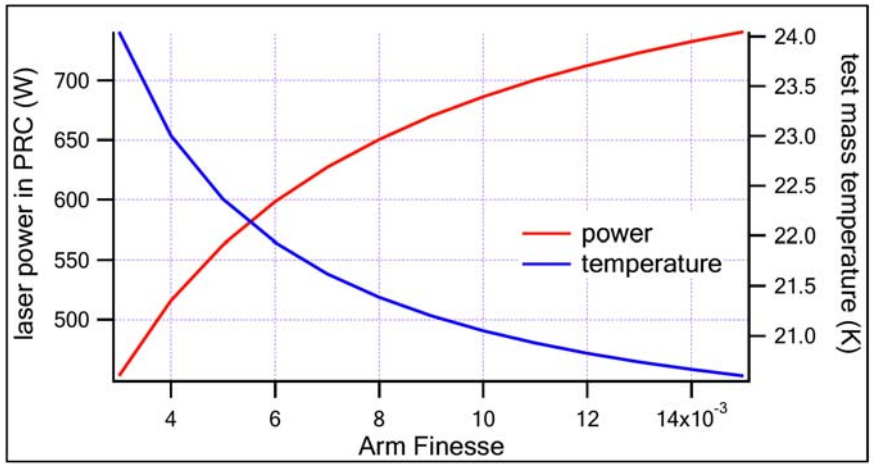
Re-optimization is necessary

Heat-flow model



- ~10ppm or arm power goes to RS
- RS temp=7K+sccattering[W]/2
- IM temp=RS temp+7 x ext-heat
- substrate abs=50ppm/cm
- coat abs=1ppm
- other heat=200mW

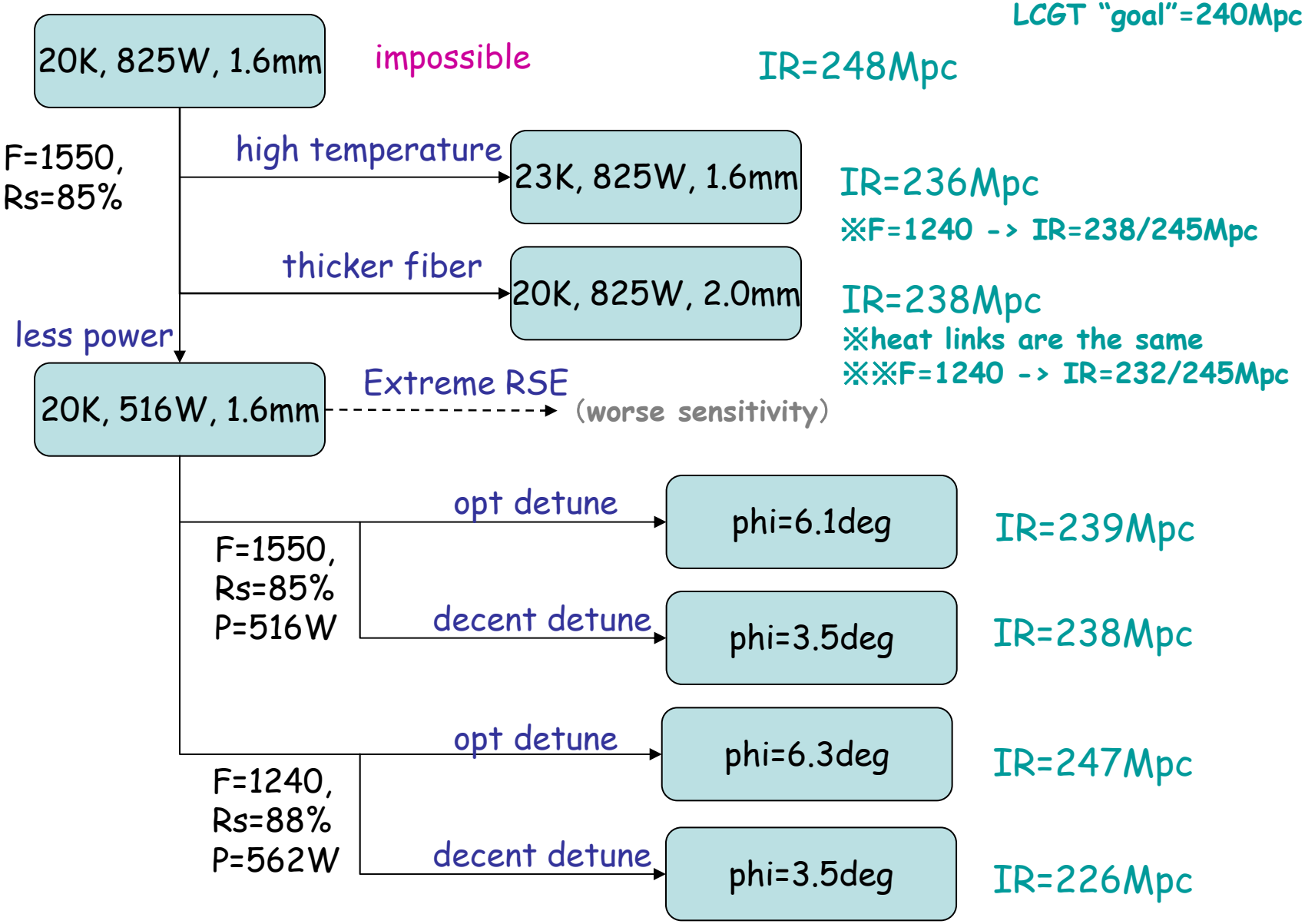
RS: inner radiation shield, PF: platform
HL: heat link, IM: intermediate mass
TM: test mass, PTC: pulse tube cooler



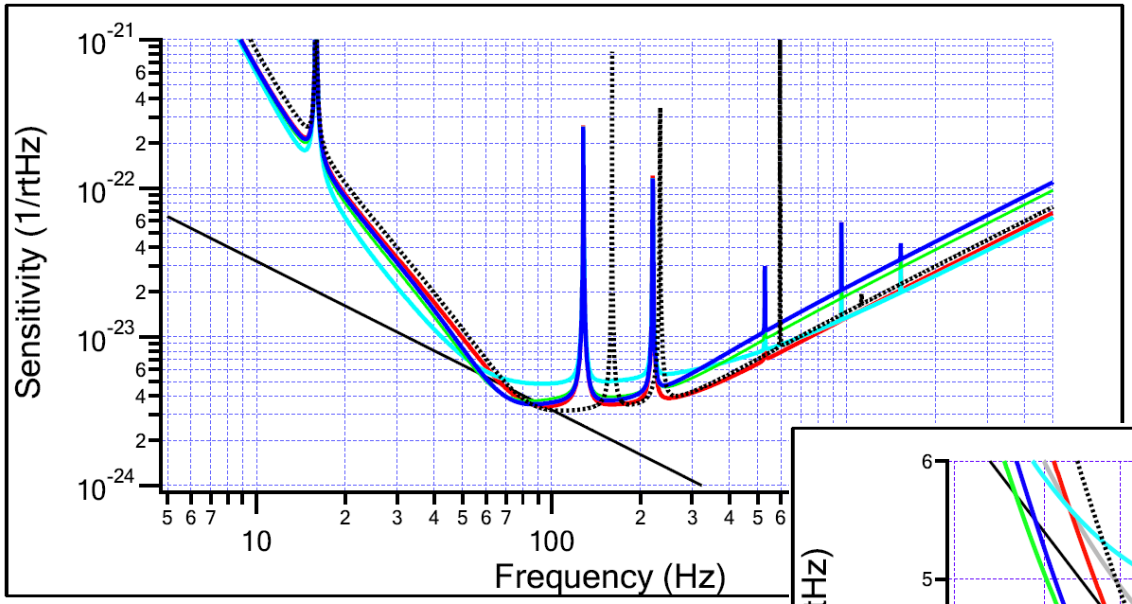
With the full power (825W), we calculate the temperature.
With the fixed temperature (20K), we calculate the power.

Flowchart

[Reference]
aLIGO IR=309Mpc
AdVirgo IR=243Mpc
LCGT "goal"=240Mpc

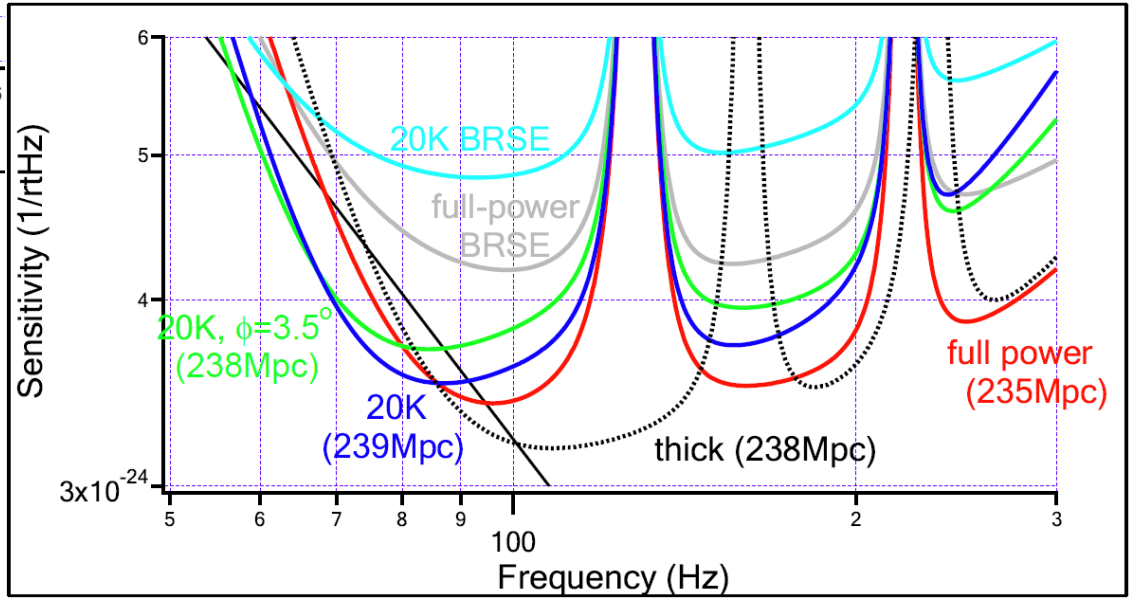


Sensitivity curves



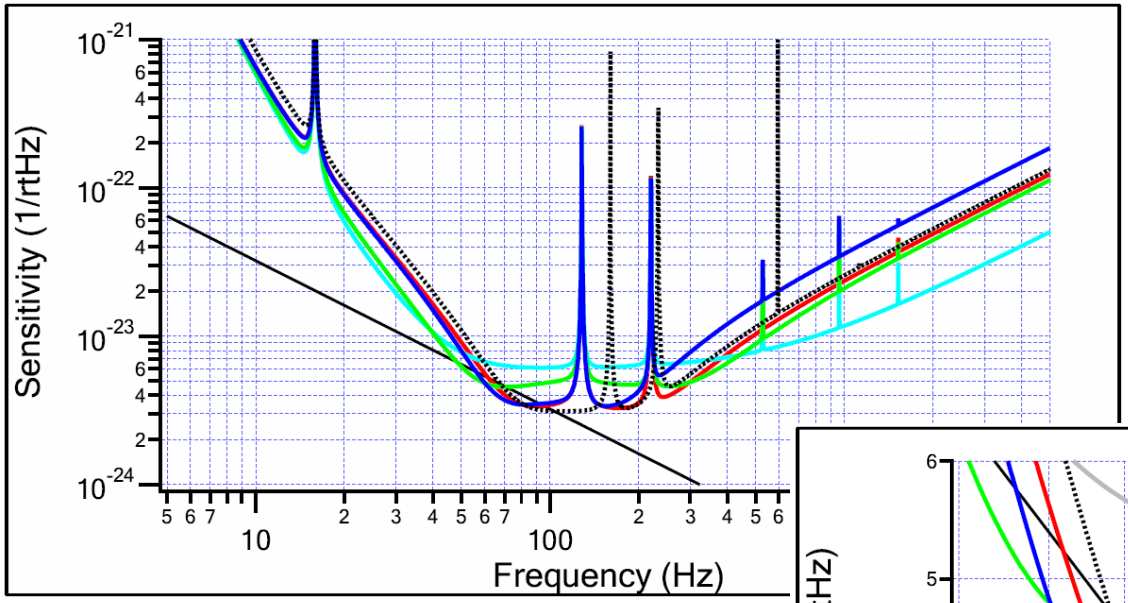
F=1550, Rs=85%

(zoom)



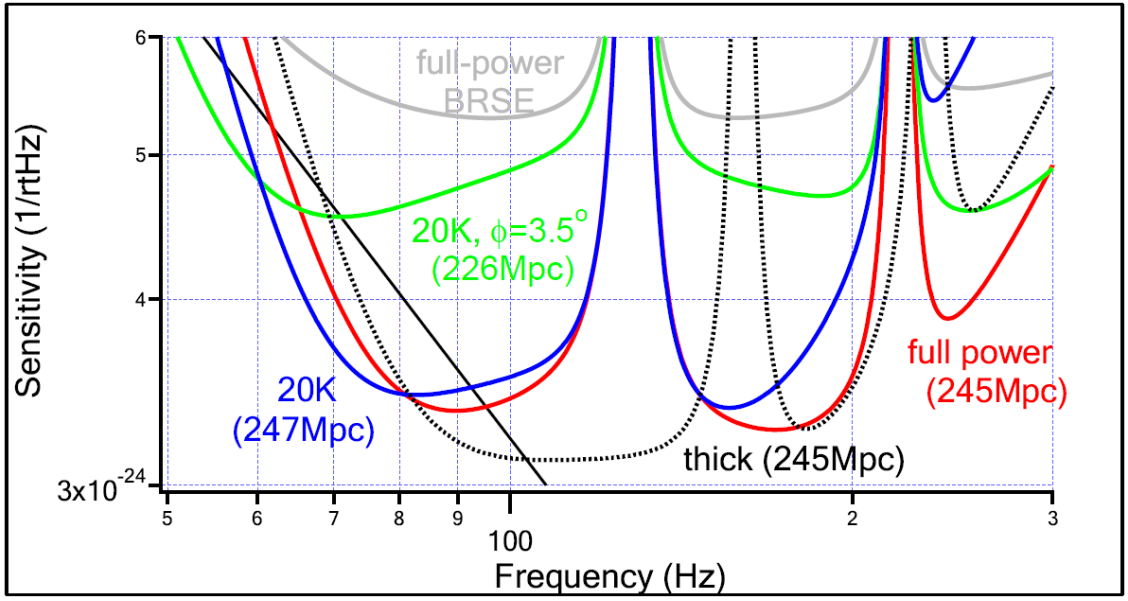
- With full power, shot noise decreases while TN increases.
->red's floor is better than blue
- With thicker fibers, temperature decreases and mirror TN improves while suspension TN increases.

Sensitivity curves



F=1240, Rs=88%

(zoom)



- Compared with F=1550, opt-DRSE BW decreases and BRSE IR gets worse (BRSE BW increases).
- Opt detune phase with 20K is big so that green is a bit far from blue.
- quantum noise is low at ~100Hz so the floor is quite flat.

Summary

		Tm (K)	Pbs (W)	IR (Mpc)	1kHz h (1/rtHz)	param. estimate
A	full power	23	825	235	1.3e-23	0.29
B	full power, thick fiber	20	825	238*	1.5e-23	0.32
C	low power, high finesse	20	516	239	2.1e-23	0.39
C'	saa. (decent detune)	20	516	238	1.9e-23	0.36
D	low power, low finesse	20	562	247	3.6e-23	0.54
D'	saa. (decent detune)	20	562	226	2.1e-23	0.37

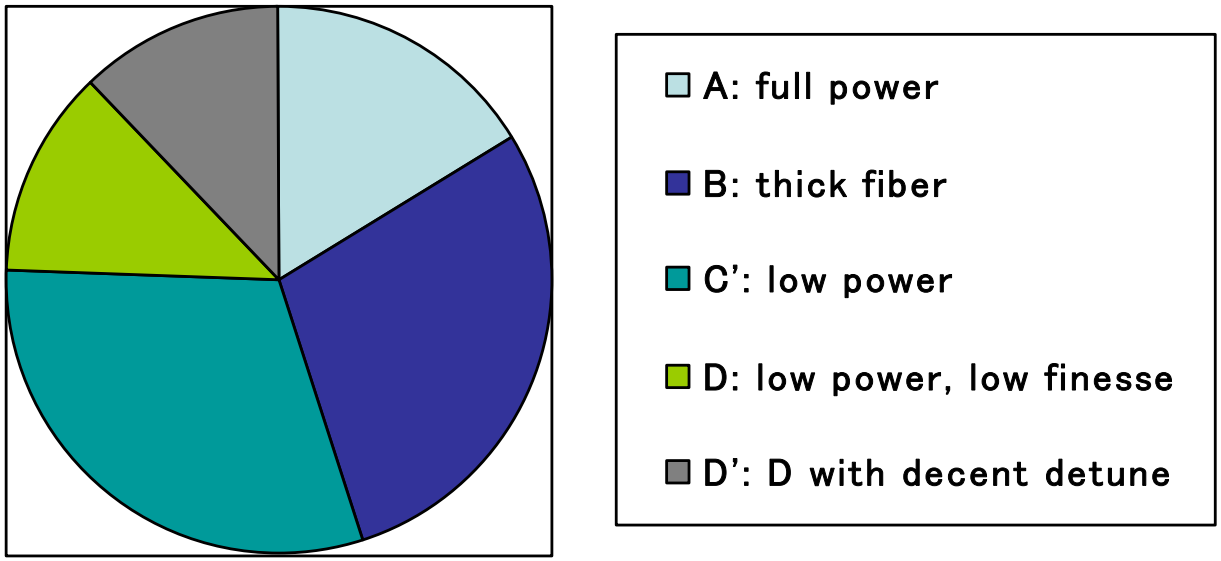
(arrival time)

* BRSE IRs are A:217Mpc, B:213Mpc, C:206Mpc, D:183Mpc
* A w/low finesse -> IR=245Mpc (opt detune), 238Mpc (3.5deg), 198Mpc (BRSE)
* B w/low finesse -> IR=245Mpc (opt detune), 231Mpc (3.5deg), 190Mpc (BRSE)
* A~D' w/ITM beam radius 4cm -> IRs are A:238Mpc, A(low-finesse):248Mpc, B:240Mpc, B(low-finesse):248Mpc, C:241Mpc, C':240Mpc, D:249Mpc, D':228Mpc.

WG members' opinions (1)

- More investigation is necessary before we could decide to use thicker fibers (Aso)
- The large peak at 110Hz should be removed somehow (Kanda)
- C seems better than D as the IR drops quite badly in D when the detune phase cannot be high (Akutsu)
- It doesn't sound right to set the low-power op the default design (Miyakawa)
- Thicker fibers can be troublesome (Uchiyama)

WG members' opinions (2)



- C' is the most robust one, which shall be the base design. After more investigation on the cryo susp and mirror absorption, we can change to B (Ando)
- A is risky as some thermal parameters are unknown. With B, we'll have no choice to recover high IR even if some parameters be better than expected. Only D has IR higher than AdV (Somiya)

Report to be written

Study report on the new LCGT setup with 22cm mirrors

LCGT Special Working Group

October 13, 2011

1 Background

We decided to purchase all the Sapphire mirrors for bLCGT within the first 3 years on the budget of the *Leading-edge Research Infrastructure Program* (LRIP). There are mainly two reasons for the decision:

- We can expect the mirror company to make better Sapphire mirrors only after we order the actual mirrors.
- It is too risky to expect additional money to buy Sapphire mirrors in the future.

It takes more than 2 years for the company to make a Sapphire mirror. Waiting for the possible extra money, we would take a risk of not having a good Sapphire mirror when it is necessary.

Since we do not have as much time as expected to develop the Sapphire mirror (namely to measure the quality of a sample mirror and feed the information back to the mirror company), the mirror speculation shall be given from the one that is currently available. The mirror size will be smaller (ϕ25 cm $\rightarrow$ ϕ22 cm) and the substrate absorption will be higher (20 ppm/cm $\rightarrow$ 50 ppm/cm), as is shown in Fig. 1. The absorption could be better but this is the reasonable number from the actual measurement where the absorption ranged 32 $\sim$ 67 ppm/cm [1].

With the new mirror speculation, radiation pressure noise and suspension thermal noise increase for the lower mass and suspension thermal noise and mirror thermal noise increase for the higher temperature according to the increasing heat absorption.

The mirror size reduction could be circumvented by taking one of the following ways:

- To use the small C-axis ITM and a large A-axis ETM
- To use a Kamaboko mirror [2]

but neither of them was chosen. As for the A-axis ETM, the radiation-pressure noise level could be the same as the original if the ETM can be as heavy as 44 kg, but suspension thermal noise of the ITM remains, and also the violin mode frequencies are different between the ITM and the ETM unless the fiber thickness is tuned. As for the Kamaboko mirror, it is pointed out that the polishing of the Kamaboko might be not as easy as that of the cylinder [3].

1

To be finished this week...

To be submitted to EC and the final decision will be made.