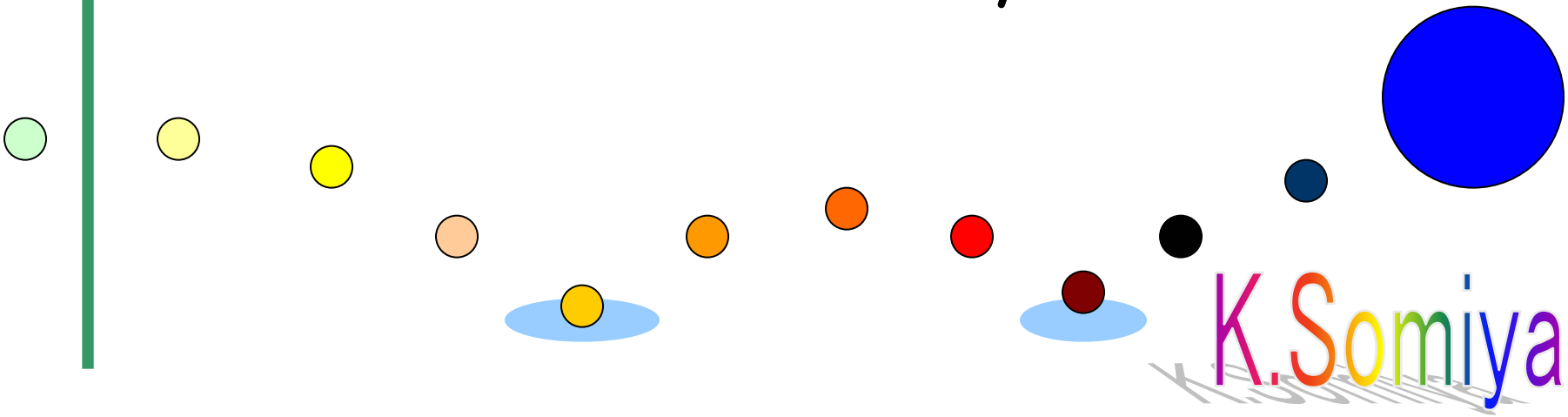
Requirements of LCGT parameters

LCGT F2F meeting @ ICRR
Feb. 2011

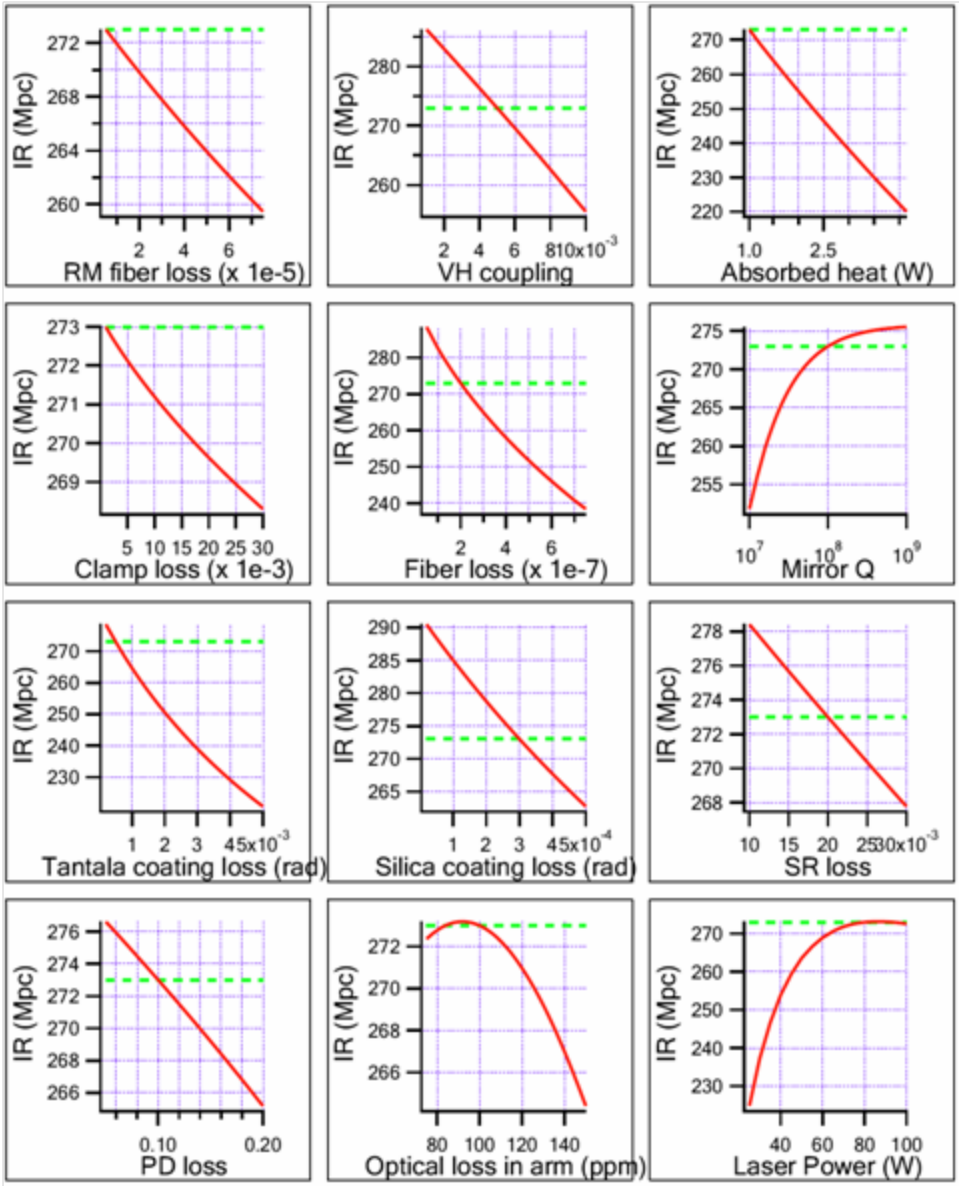
Waseda Inst for Advanced Study
Kentaro Somiya



Contents

- Fundamental noise parameters
  - LCGT design sensitivity is determined by QN, TN, seismic
  - Deterioration of the parameters degrades the sensitivity
- Other noise sources
  - Residual gas, laser noise, control-loop noise, etc.
  - Each noise should be 1/10 or less of the design sensitivity
- Interface parameters
  - Listing up all the parameters
  - Recognizing common parameters to subsystems
- Discussions

Requirements for QN/TN parameters



- IR reduction by degrade of some major parameters
- IFO setup is fixed
- Most of them changes the IR almost linearly
- Let's see the values that cause 1-2% IR reduction for each parameter

Optical loss and laser power

IR reduction	0%	1%	2%
Carrier power	81W	64W	57W
Arm loss	100ppm	124ppm	138ppm
SRC loss	2%	2.5%	3.0%
PD loss	10%	13.6%	17.1%

- IFO setup is fixed (detuning and DC readout phase)
- Arm loss causes (i) PRG reduction (ii) signal reduction
- SRC loss and PD loss cause signal reduction
- IR reduction due to the mode mismatching has been recently calculated by Nishida-san (TBA)

Mirror Qs and temperature

IR reduction	0%	1%	2%
Temperature (Absorbed heat)	20K (1W)	20.7K (1.16W)	21.4K (1.31W)
Silica coating loss	3e-4	3.5e-4	4.0e-4
Tantala coating loss	5e-4	6.6e-4	8.2e-4
Substrate Q	1e8	5.0e7	3.3e7

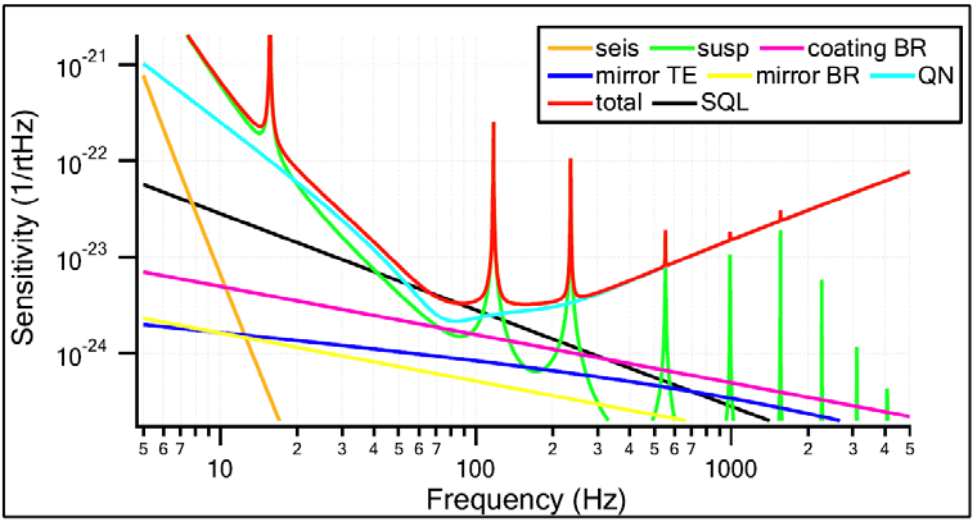
- Increasing heat absorption raises the temperature and increases thermal noise
- Measured coating losses are 5e-4/8e-4 but the values can be better with a proper annealing

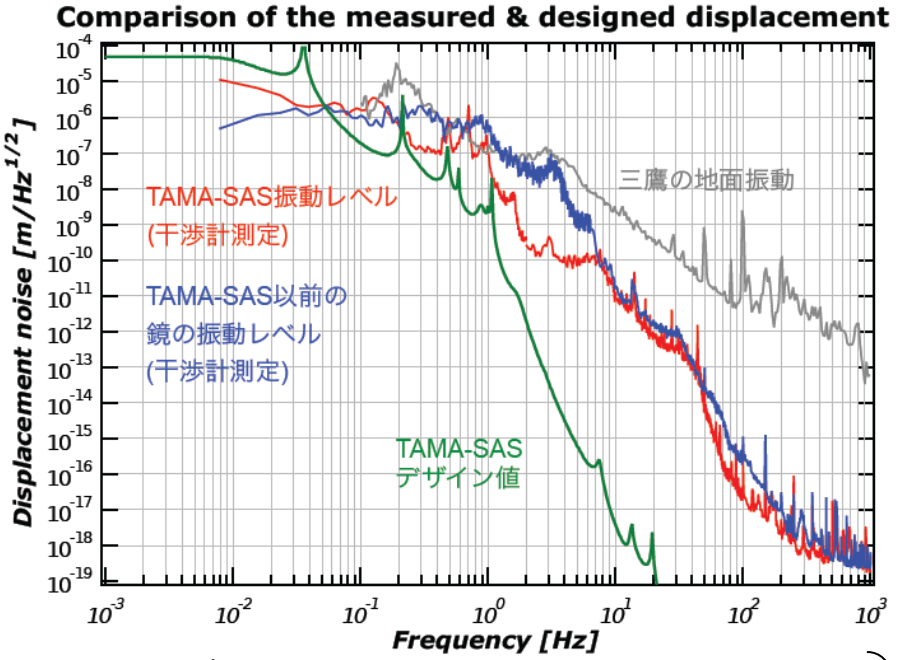
Fiber losses and VH coupling

IR reduction	0%	1%	2%
Sapphire fiber (TM)	2e-7	2.32e-7	2.67e-7
Tungsten fiber (IM)	1e-4	N/A	
BeCu fiber (RM)	5e-6	1.8e-5	3.1e-5
Clamp loss	1e-3	1.6e-2	3.6e-2
VH coupling	1:200	1:172	1:152

- TM, RM, and VHC are severe
- IM TN is diluted with a mini-GAS btw IM and PF
- Mini-GAS resonance is set 0.4Hz (-> 3Hz?)
- The robe of vertical resonance may increase

Requirements for seismic isolation





left: LCGT design (seismic noise in orange)
right: TAMA seismic noise with SAS (design in green, result in blue)

- 5-order degradation makes only 30% IR reduction
- In fact, it is easy for such a thing to happen
- Takahashi-san says the worst-case noise level can be calculated

Other noise sources

Excess noise should be 1/10 or less of the design sensitivity

- **Laser noise**

  Transfer function has been calculated analytically, but it's probably better to use Optickle code for more detailed calculation (>> ISC task)

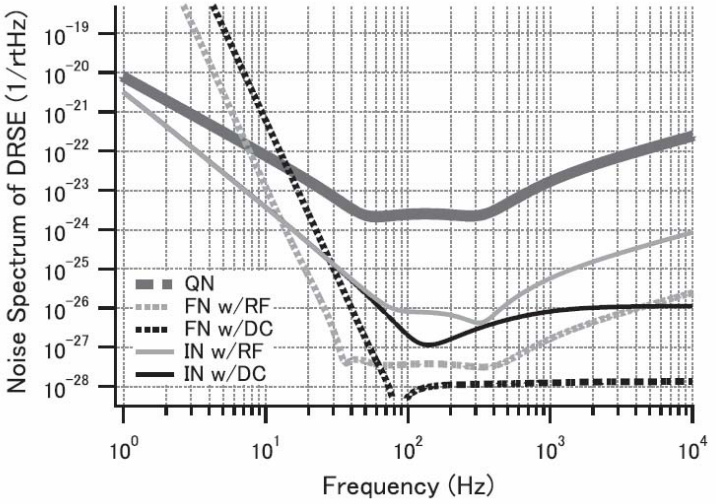
- **Loop noise**

  Optickle code can calculate loop noise (>> ISC task). Number of issues remain.

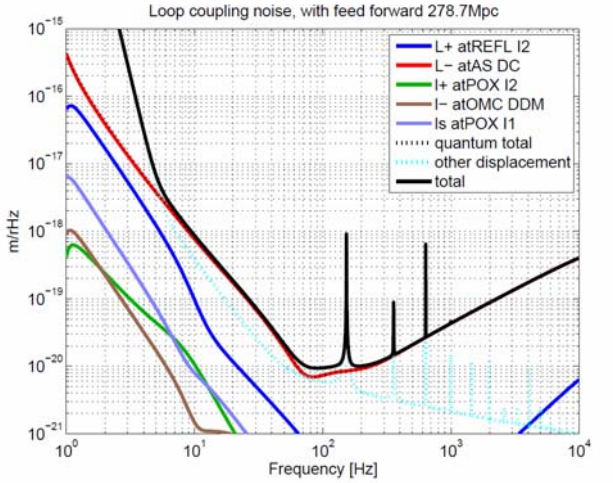
- **Residual gas noise**

  Requirement for the vacuum level is given:
  P < 5e-7 Pa (with positive g-factor)
  P < 3e-7 Pa (with negative g-factor)

- **Analog circuit noise**
- **Digital-system noise**



Laser noise TF for old aLIGO



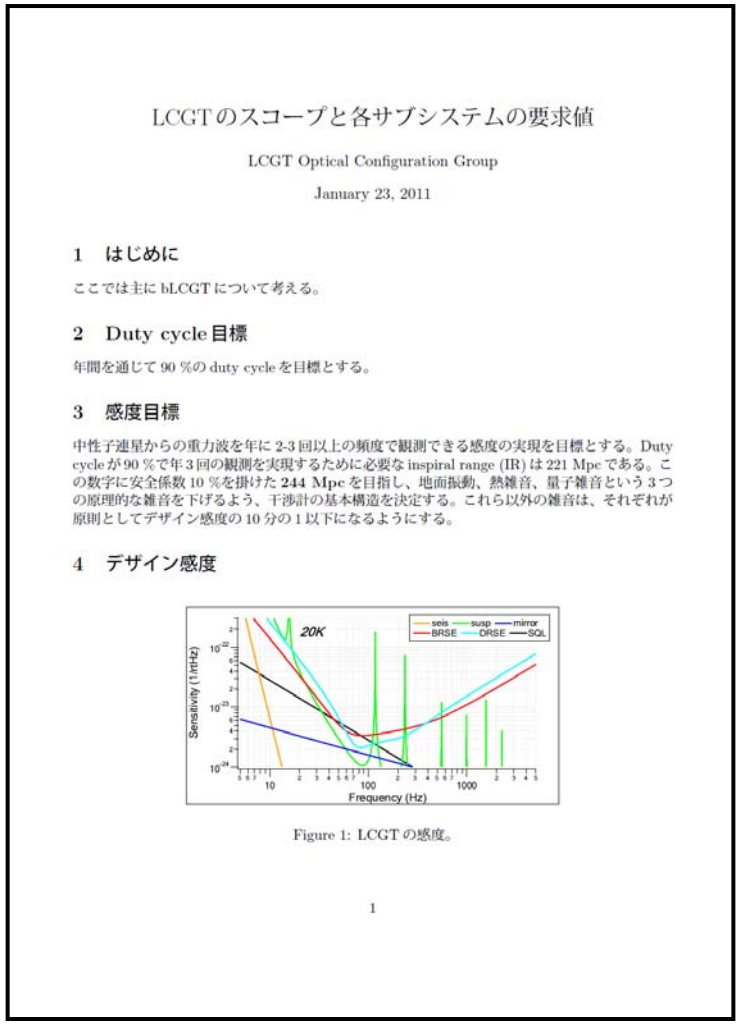
Loop noise of LCGT

Cleanliness

- Facility support group is required to find a leader!
- Good mirrors can be easily contaminated on the way to its place
- LIGO has a lot of reports on this issue
- We will have only one spare mirror per arm
- Different requirements for different places:
  - CLASS 10,000 in the tunnel (?)
  - CLASS 1,000 in the lab
  - CLASS 100 in the assembly area (clean room)
  - No particles >1um in the vacuum chamber

(Those numbers are very preliminary)

Requirement report



LCGTのスコープと各サブシステムの要求値

LCGT Optical Configuration Group

January 23, 2011

1 はじめに

ここでは主にbLCGTについて考える。

2 Duty cycle目標

年間を通じて90 %のduty cycleを目標とする。

3 感度目標

中性子連星からの重力波を年に2-3回以上の頻度で観測できる感度の実現を目標とする。Duty cycleが90 %で年3回の観測を実現するために必要なinspiral range (IR)は221 Mpcである。この数字に安全係数10 %を掛けた**244 Mpc**を目指し、地面振動、熱雑音、量子雑音という3つの原理的な雑音を下げるよう、干渉計の基本構造を決定する。これら以外の雑音は、それぞれが原則としてデザイン感度の10分の1以下になるようにする。

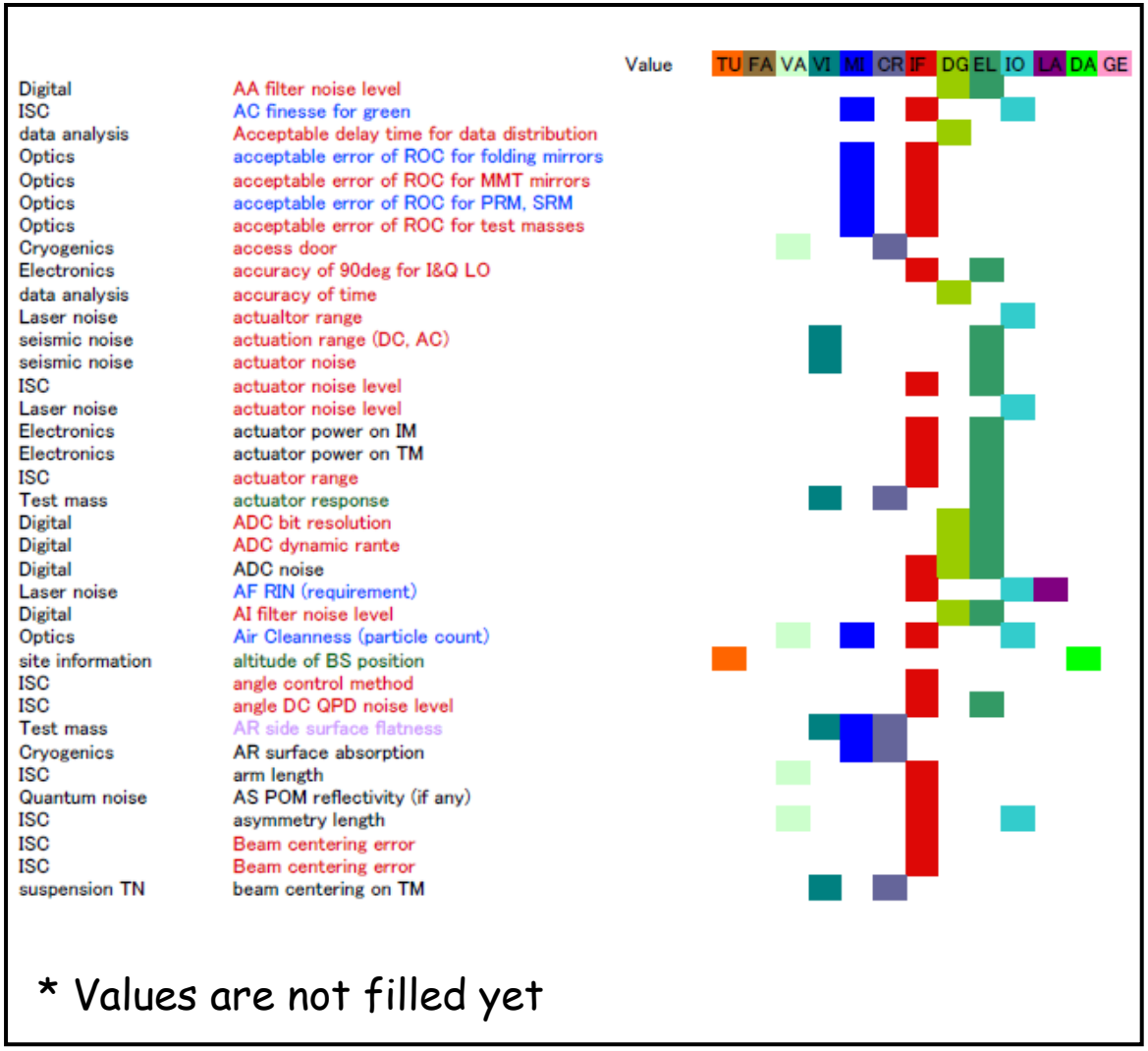
4 デザイン感度

Figure 1: LCGTの感度。

1

- Requirements are to be set with (i) excess noise level (ii) feasibility taken into account
- Configuration group is preparing a report with Prof. Kawamura and Prof. Ando.
- We will ask subsystems for some helps and opinions
- The report will show requirements for each subsystem

Interface parameters



* Values are not filled yet

- We've listed up so far 600+ parameters
- Related subsystems are marked
- List will be distributed to subsystems

End