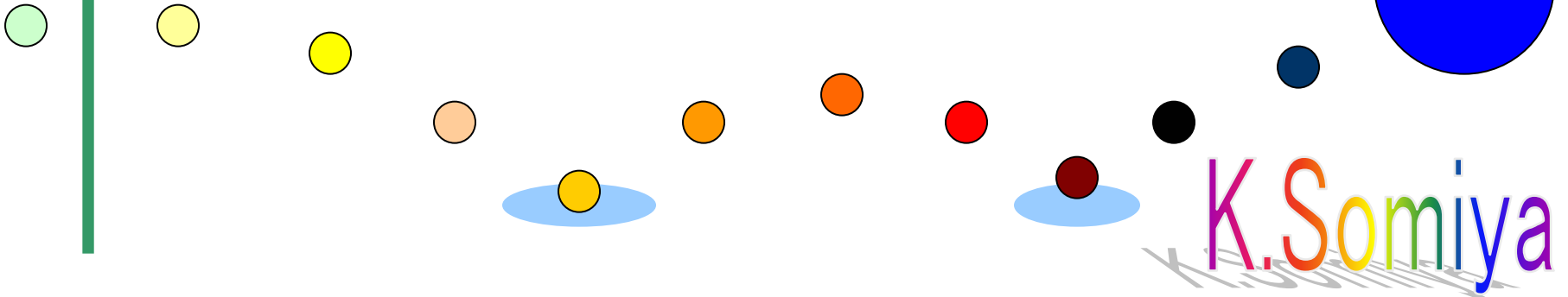# Requirements of LCGT parameters

LCGT F2F meeting @ ICRR
Feb. 2011

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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
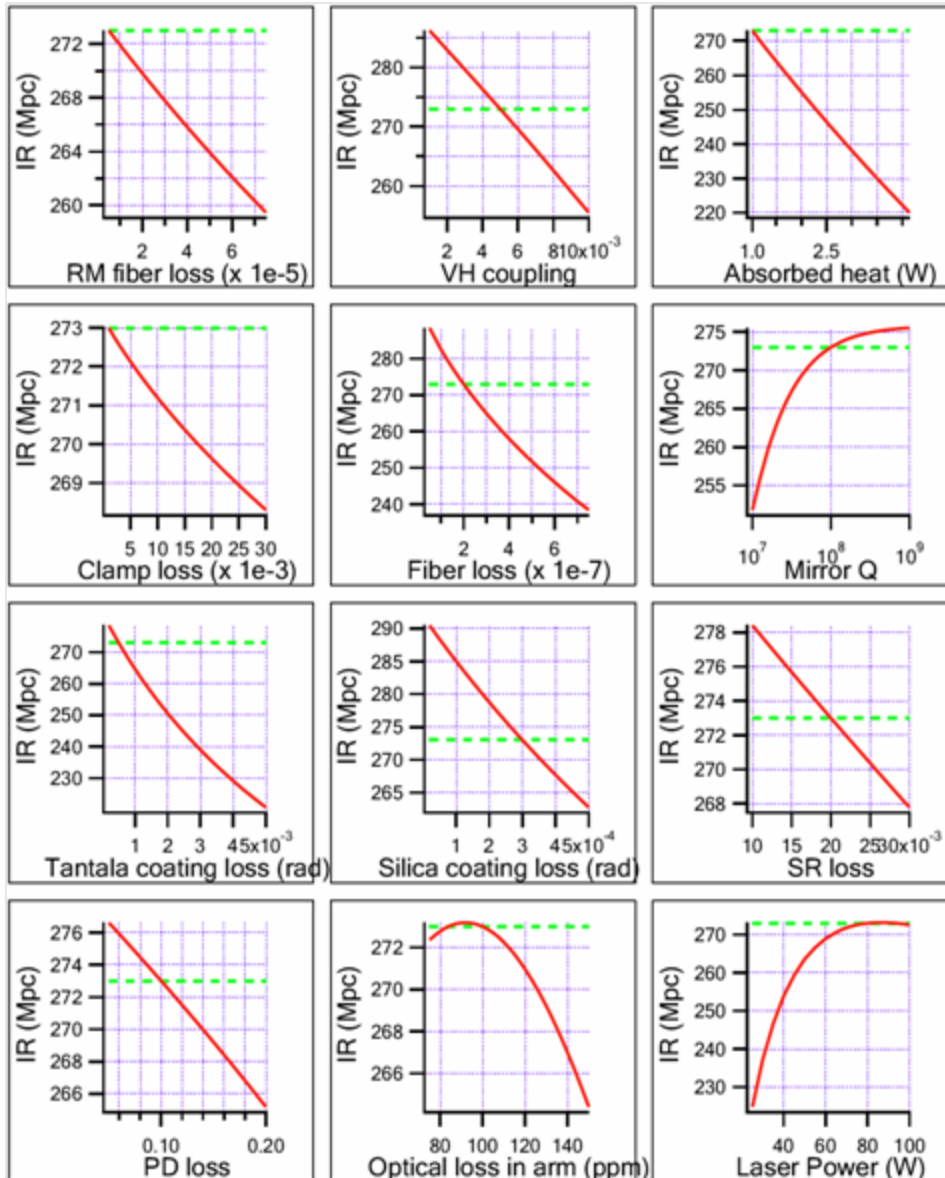
- **IR reduction by degrade of some major parameters**

- **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

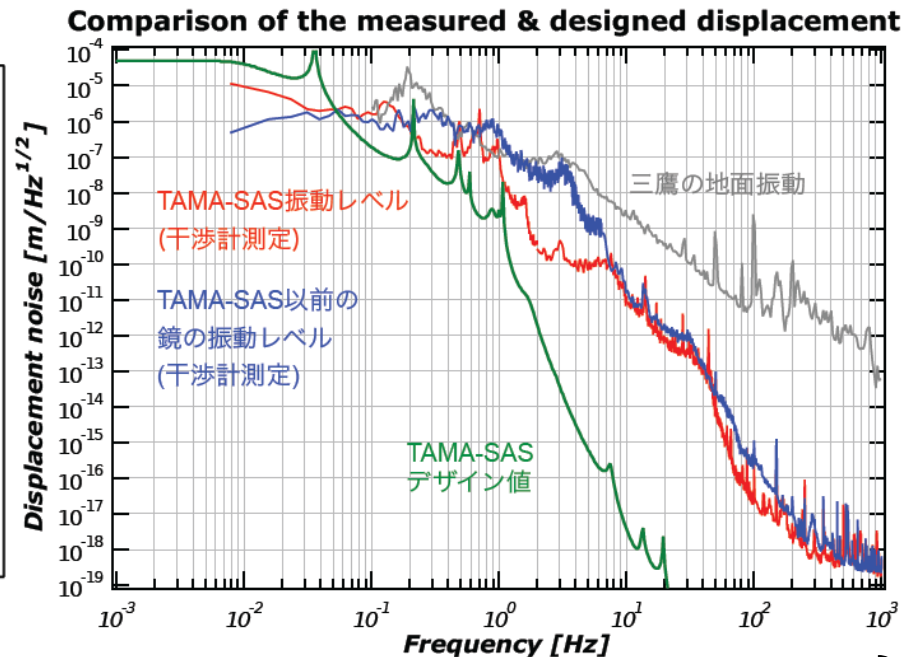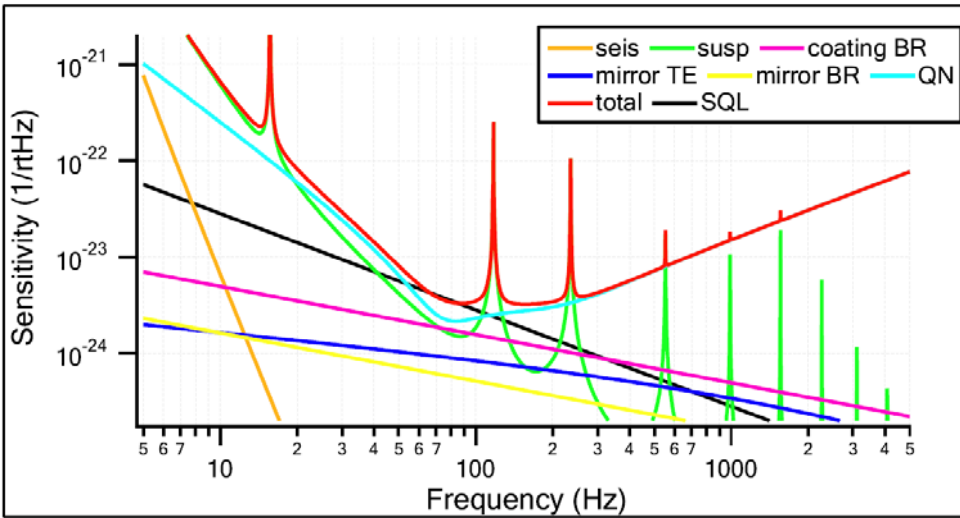| IR reduction	0%	1%	2%
Temperature (Absorbed heat)	20K (1W)	20.7K (1.16W)	21.4K (1.31W)
Silica coating loss	3e-4	3.5e-4	4.0e-4
Tantala coating loss	5e-4	6.6e-4	8.2e-4
Substrate Q	1e8	5.0e7	3.3e7

- 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

Comparison of the measured & designed displacement

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

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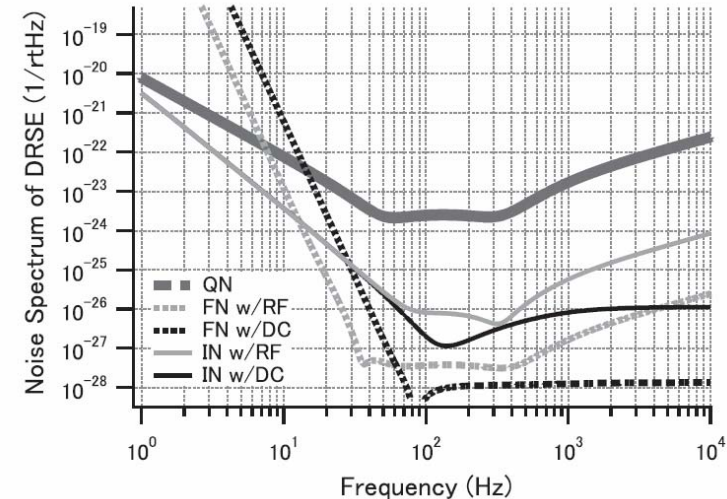
  Requirement for the vacuum level is given:
  P < 5e-7 Pa (with positive g-factor)
  P < 3e-7 Pa (with negative g-factor)

- ## Analog circuit noise
- ## Digital-system noise

Laser noise TF for old aLIGO
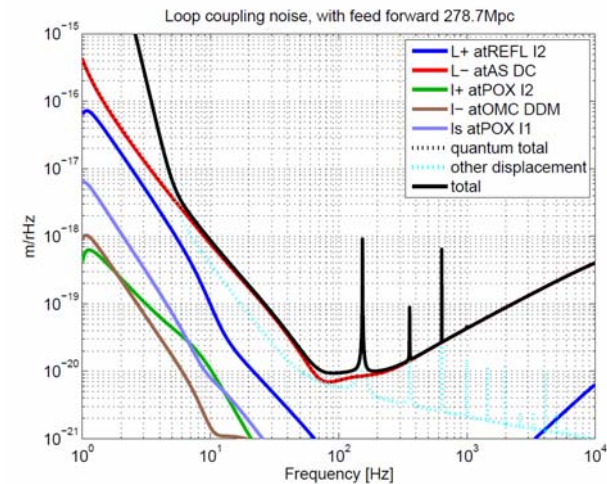
Loop noise of LCGT

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

- 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.
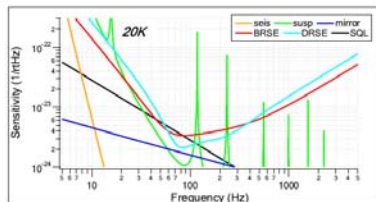
- We will ask subsystems for some helps and opinions

- The report will show requirements for each subsystem

Interface parameters

		Value	TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	DA	GE
Digital	AA filter noise level														
ISC	AC finesse for green														
data analysis	Acceptable delay time for data distribution														
Optics	acceptable error of ROC for folding mirrors														
Optics	acceptable error of ROC for MMT mirrors														
Optics	acceptable error of ROC for PRM, SRM														
Optics	acceptable error of ROC for test masses														
Cryogenics	access door														
Electronics	accuracy of 90deg for I&Q LO														
data analysis	accuracy of time														
Laser noise	actualtor range														
seismic noise	actuation range (DC, AC)														
seismic noise	actuator noise														
ISC	actuator noise level														
Laser noise	actuator noise level														
Electronics	actuator power on IM														
Electronics	actuator power on TM														
ISC	actuator range														
Test mass	actuator response														
Digital	ADC bit resolution														
Digital	ADC dynamic rante														
Digital	ADC noise														
Laser noise	AF RIN (requirement)														
Digital	AI filter noise level														
Optics	Air Cleanness (particle count)														
site information	altitude of BS position														
ISC	angle control method														
ISC	angle DC QPD noise level														
Test mass	AR side surface flatness														
Cryogenics	AR surface absorption														
ISC	arm length														
Quantum noise	AS POM reflectivity (if any)														
ISC	asymmetry length														
ISC	Beam centering error														
ISC	Beam centering error														
suspension TN	beam centering on TM														

⋮

* Values are not filled yet

- We've listed up so far 600+ parameters

- Related subsystems are marked

- List will be distributed to subsystems

End