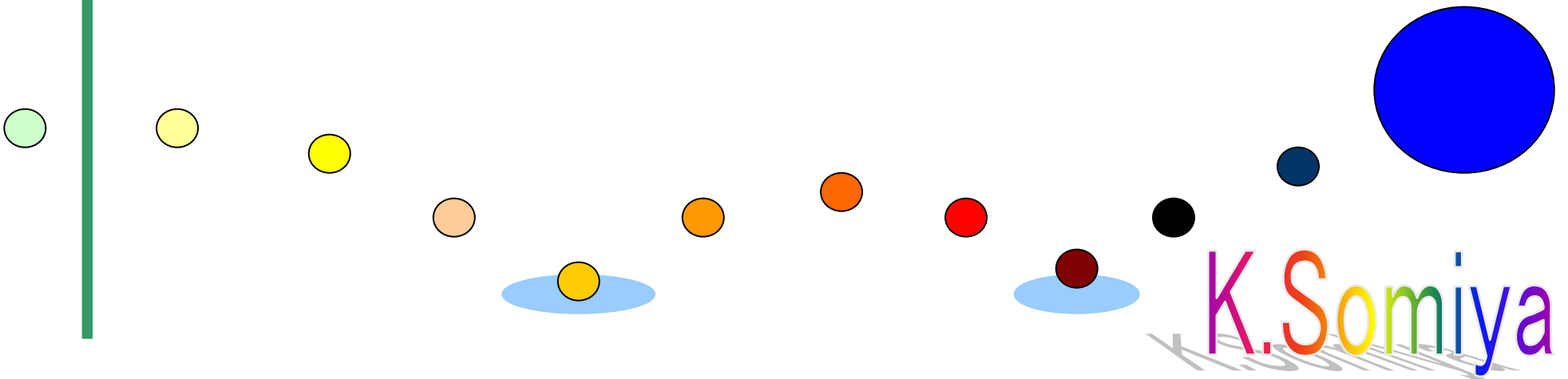


iLCGT design

LCGT F2F meeting @ ICRR
Sep. 2010

Optical Configuration Group



Concept of iLCGT

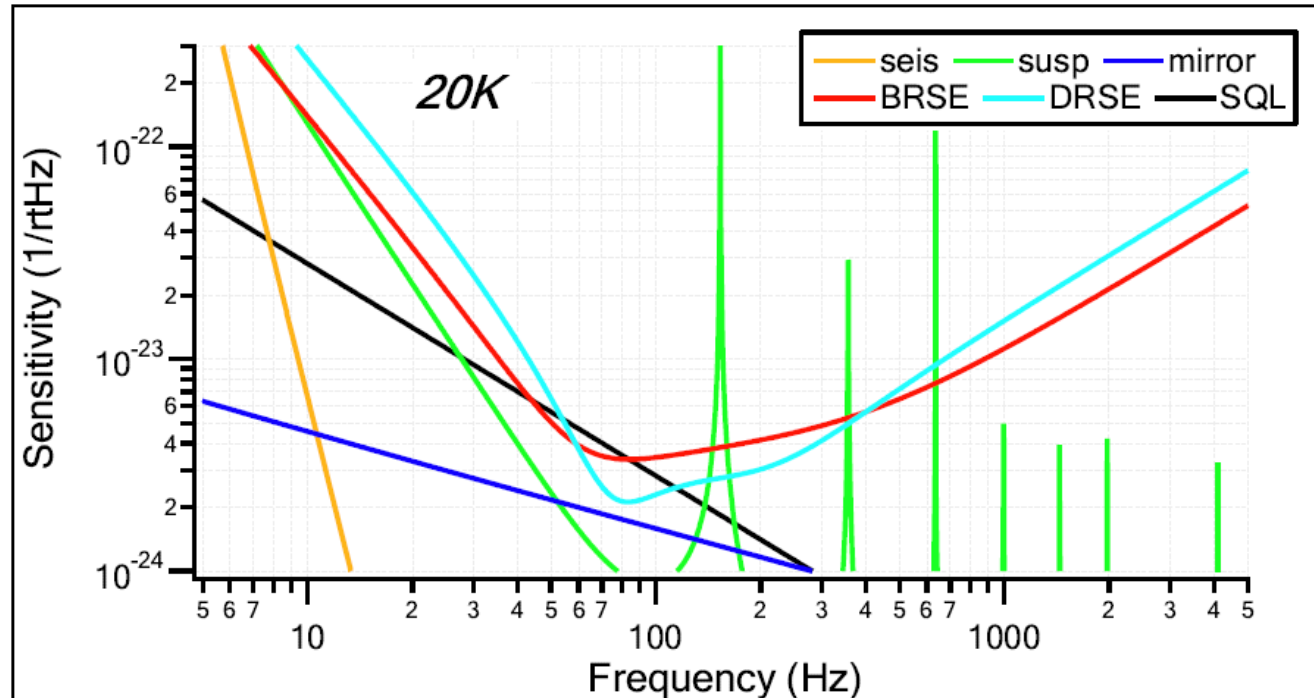
- **short-term observation in 2014 (Oct.)**
- **final R&D to operate a 3km interferometer**
- **simple design**
- **smooth transition to baseline LCGT**

Optical Configuration Group

- **review of some LCGT parameters that should be fixed before constructing iLCGT**
~ mass, suspension, cavity length, etc.
- **finalization of iLCGT parameters**
~ finesse, laser power, mass, etc.
- **risk management**
- **provision of requirements and tolerances**
- **group members:** M.Ando, K.Arai, Y.Aso, O.Miyakawa, S.Miyoki, H.Yamamoto, K.Yamamoto, and K.Somiya

Review of the parameters

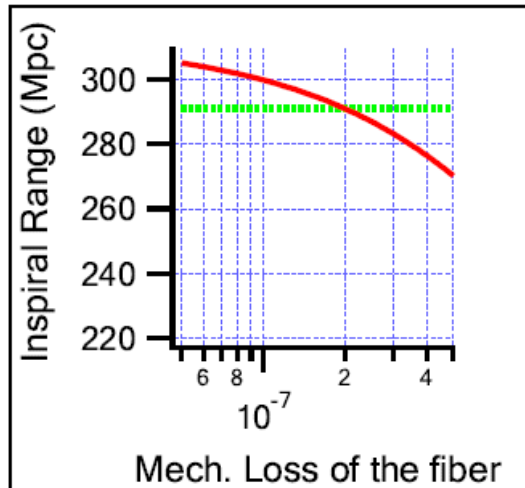
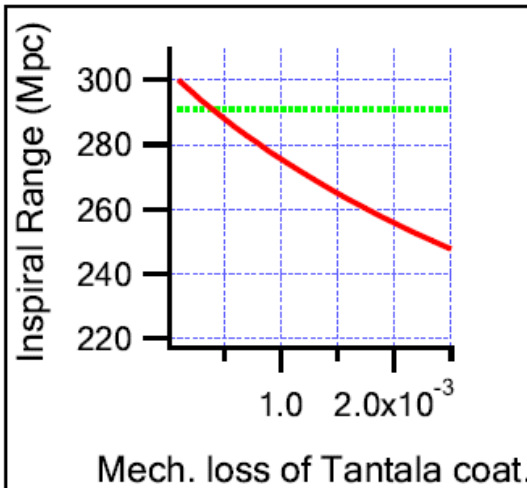
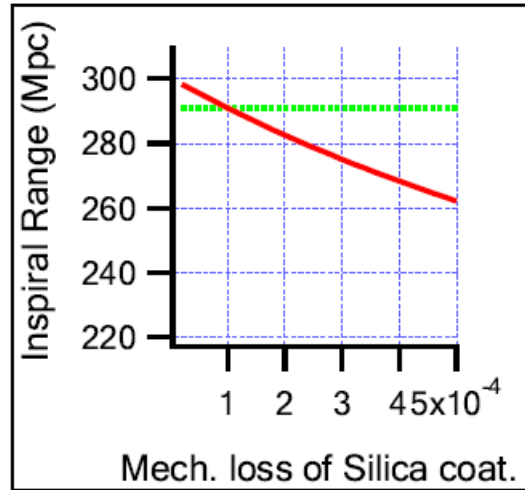
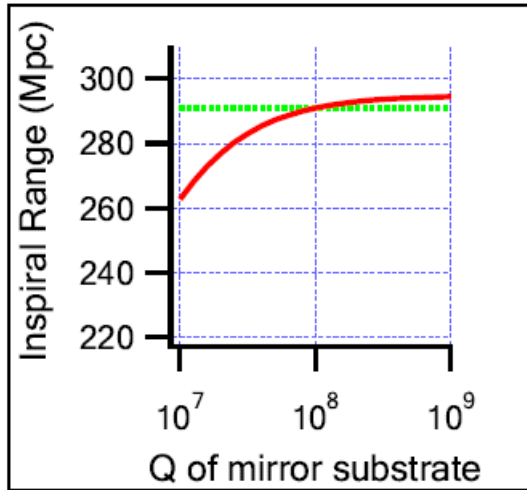
Updated LCGT sensitivity curve (IR=291Mpc w/DRSE)



- thermoelastic noise (high freq)
- beam radius (3cm to 3.5cm)
- seismic noise (heat link vibration)
- detune phase and homodyne phase are re-optimized
- vertical susp TN hasn't been included yet

Tolerance of some parameters (1)

~ mechanical losses ~



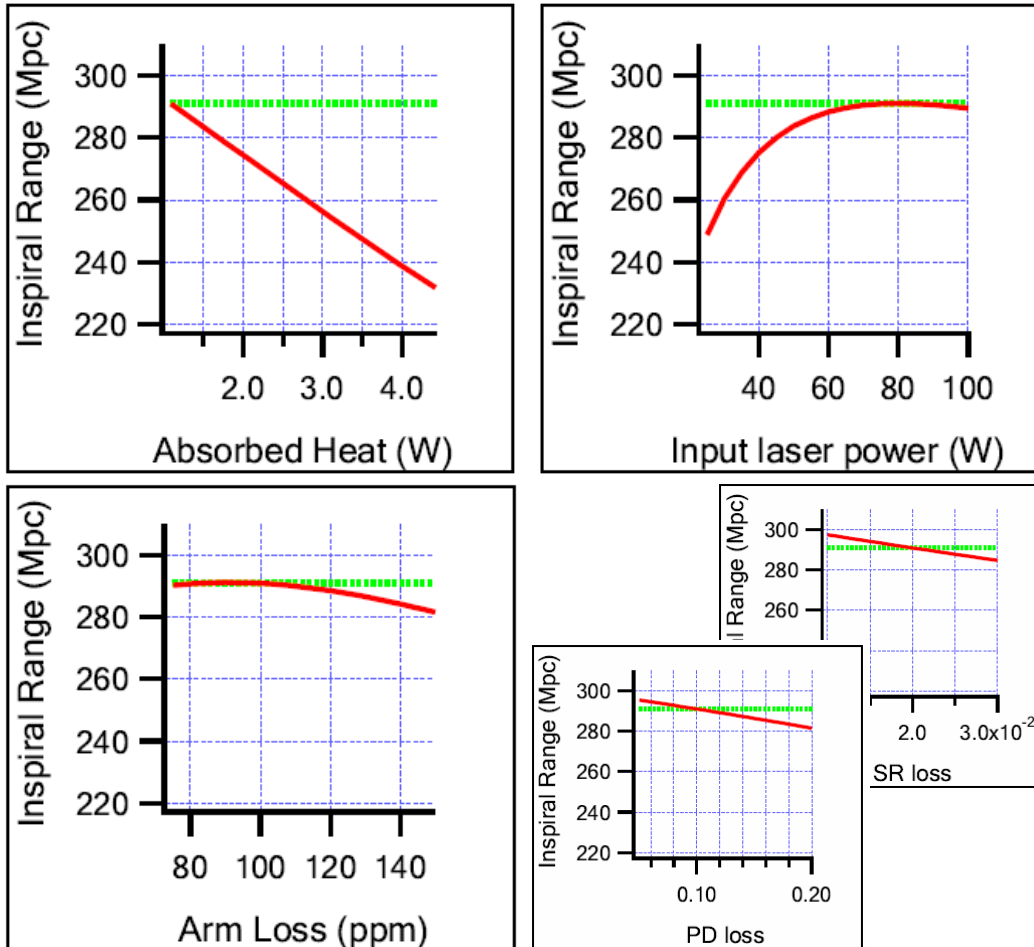
- Tantara loss and fiber loss are a bit severe
- Estimated losses of the coatings are 2 times higher than those in room temp.
- Fiber loss could be low due to its thickness

We don't see big problems with the estimated values.

Curves cross the green line at the estimated values.

Tolerance of some parameters (2)

~ heat, power, optical losses ~



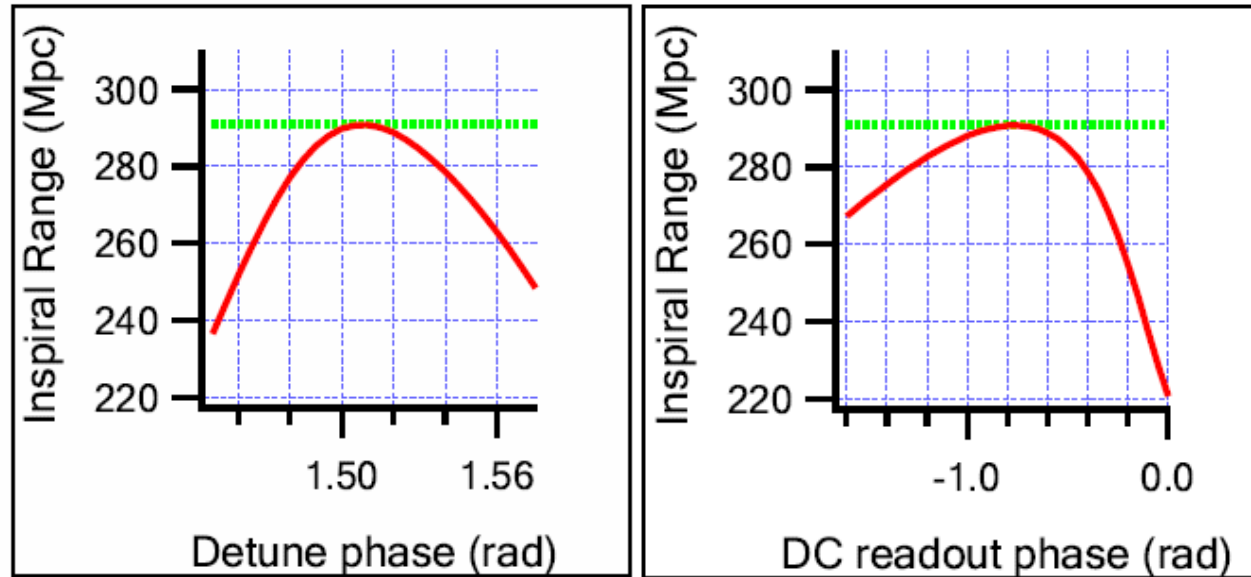
- Estimated input power is 80.7W (PRG=10.22), and detune/HD phases are fixed
- Arm loss causes reduction of PRG and signal gain
- Increasing absorption leads to increasing temperature

Mirror losses are not as severe as we thought.

Curves cross the green line at the estimated values.

Tolerance of some parameters (3)

~ detune and homodyne (DC) phases ~

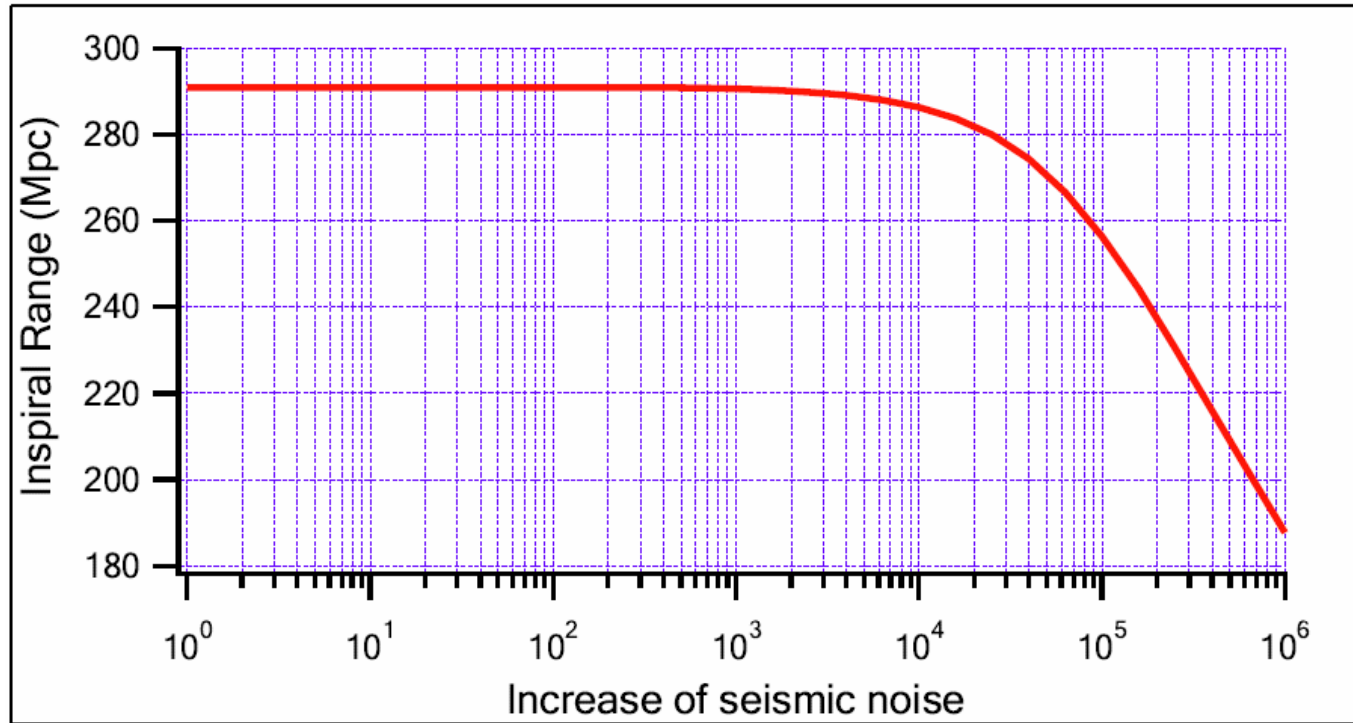


Challenging parts cannot be seen from these graphs.

- DRSE with optimal HD phase: IR=291Mpc
- BRSE with optimal HD phase: IR=259Mpc
- BRSE with fixed HD phase (90deg): IR=242Mpc

Tolerance of some parameters (4)

~ increase of seismic noise ~



Challenging parts cannot be seen from these graphs.

Issues would rather be robust control, lower control band, etc.

To be checked

- **Vertical suspension thermal noise**
- **Upper-stage suspension thermal noise**
- **ISC parameters** e.g. higher-order modes at OMC-REFL
- **Non-linear noise around the violin modes**

... anything else?

Risk management (1)

~ small issues on detuning ~

(i) Sideband imbalances

Imbalance between upper and lower 11.25MHz SBs may cause saturation of the PD output;

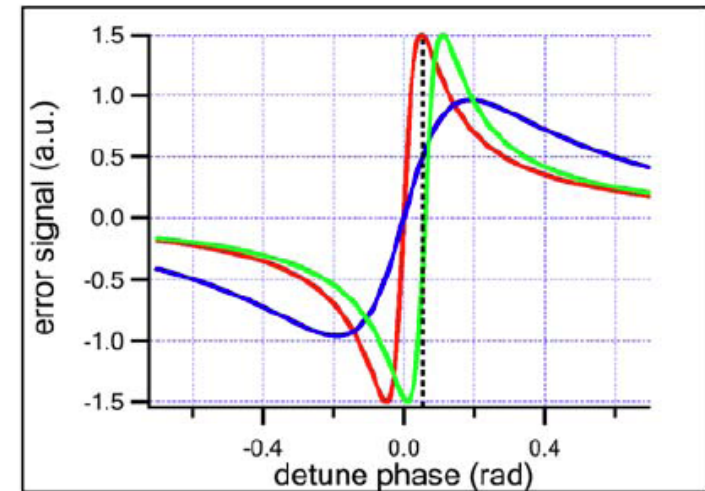
This is solvable by adding offset current.

(ii) Offset locking

If the zero-crossing point is for BRSE, offset voltage is to be added; this won't be hard but hasn't been tested.

SRC length differs by 27cm to have the zero-crossing for DRSE.

It would be better to have the zero-crossing for BRSE so that BRSE could be easily realized in the case we decide to start observation earlier.



Risk management (2)

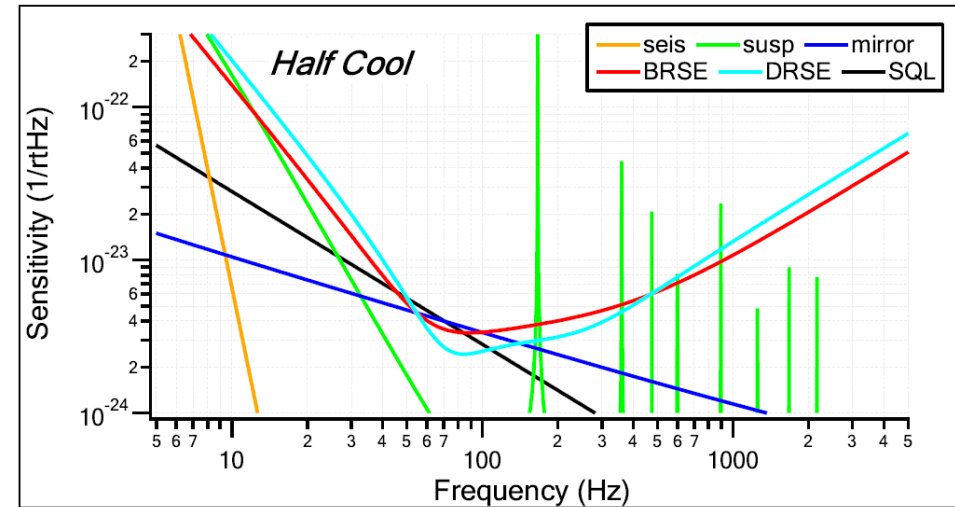
~ availability of good sapphire ~

(i) ETM is ok, ITM may be not

- birefringence
- internal scattering
- heat absorption

(ii) Half-cool operation as an option

- 300K Silica ITM + 20K Sapphire ETM
- IR is 232Mpc with 30kg ITM (239Mpc w/40kg)

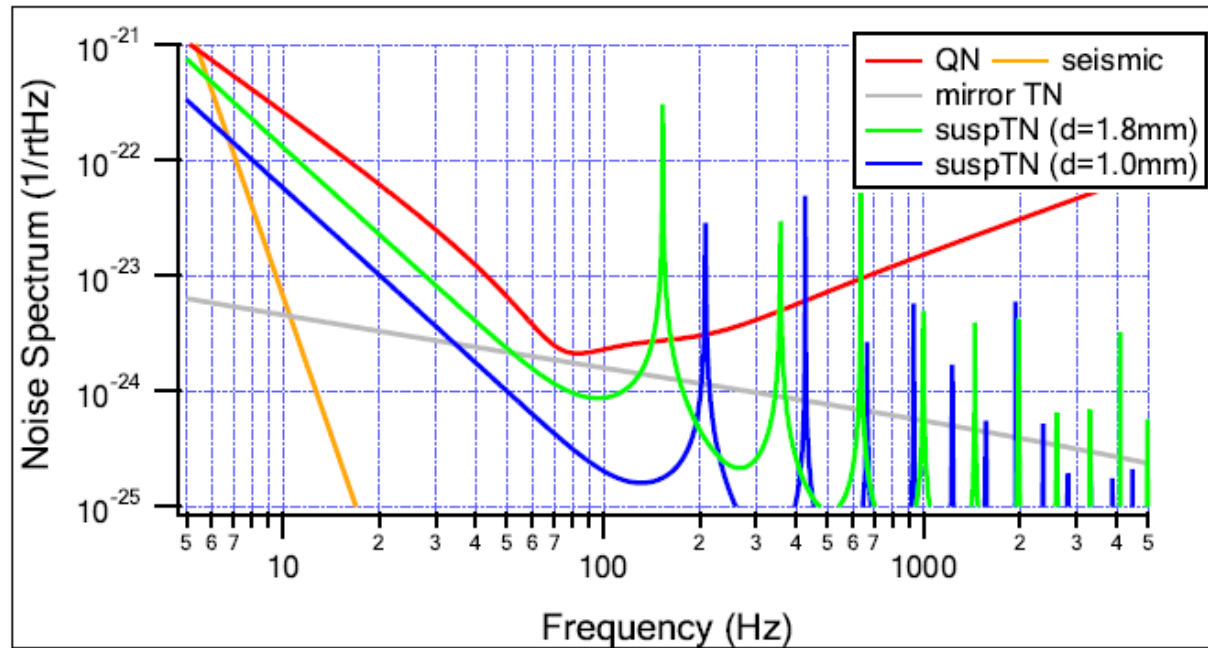


(232Mpc with DRSE, 220Mpc with BRSE)

- **30kg Silica ITM is good for iLCGT**
 - Better with 40kg but not so necessary
- **Better to prepare for TCS**
 - Maybe necessary for BS anyway (to be checked)

Risk management (3)

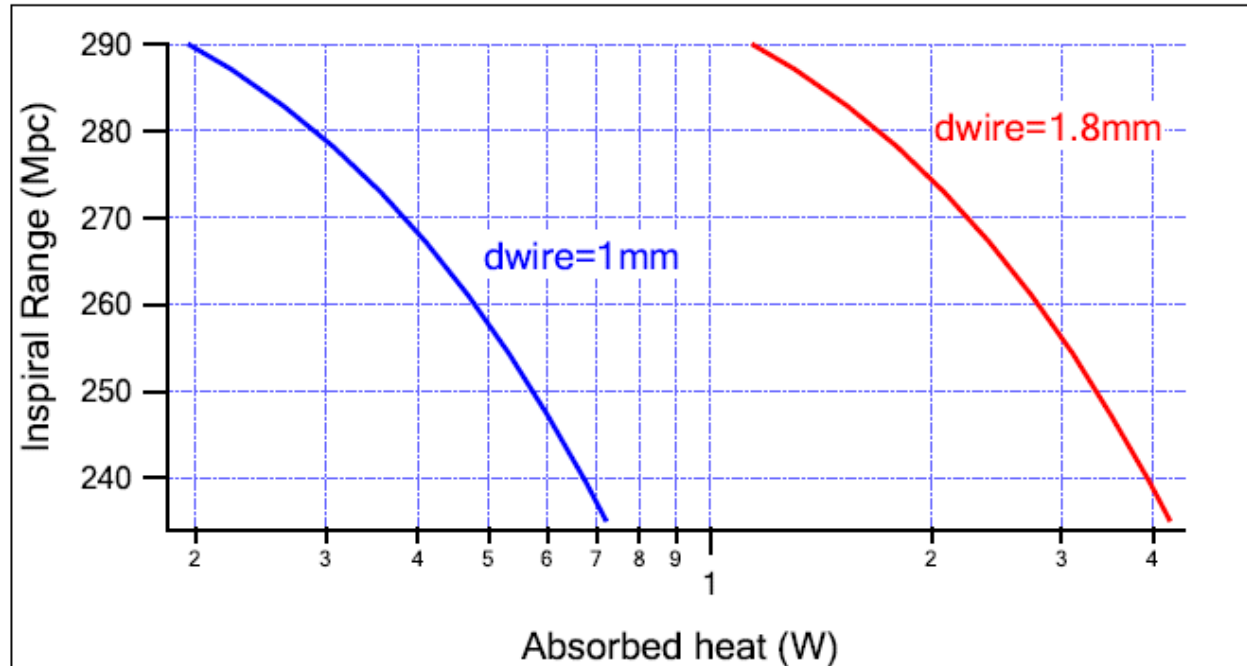
~ sapphire fiber and non-stationary noise (i) ~



- Low-freq noise couples with violin modes and may degrade the sensitivity
- Violin modes can be driven away with a thinner fiber but it reduces the cooling capability

Risk management (3)

~ sapphire fiber and non-stationary noise (ii) ~



- With a thin fiber, mirror temperature increases and IR goes down
- IR with a thick fiber may be worse for non-linear noise
- Besides, fiber fabrication and bonding is another issue

iLCGT design

As we've seen, some issues remain...

- SRC length?
- Mass (and size) ?
- Fiber length?
- some ISC stuff: MZ, AM, etc.

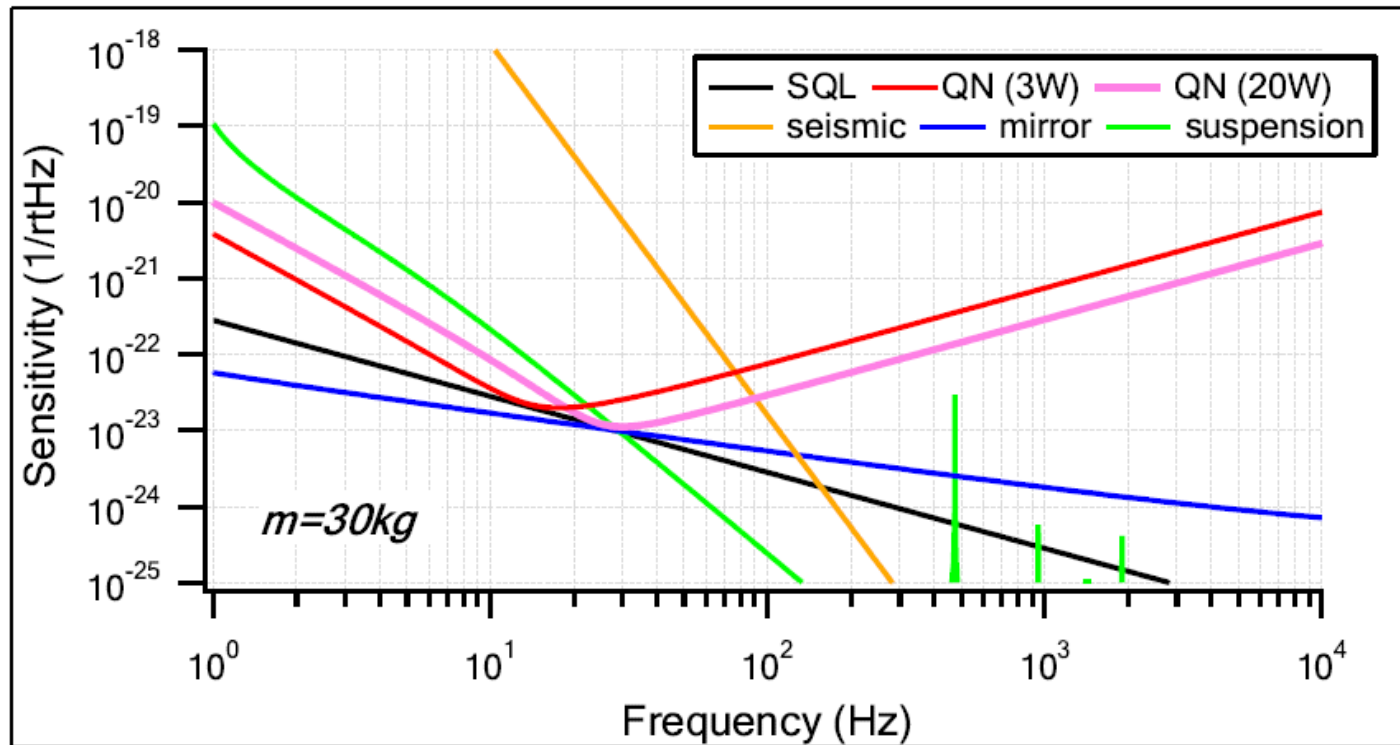
These should be fixed before the construction.

The following things are already fixed (supposedly).

- B-type suspensions (double pendulum)
- FPMI (no PR, no RSE)
- Finesse is 1550
- RF readout (no OMC)

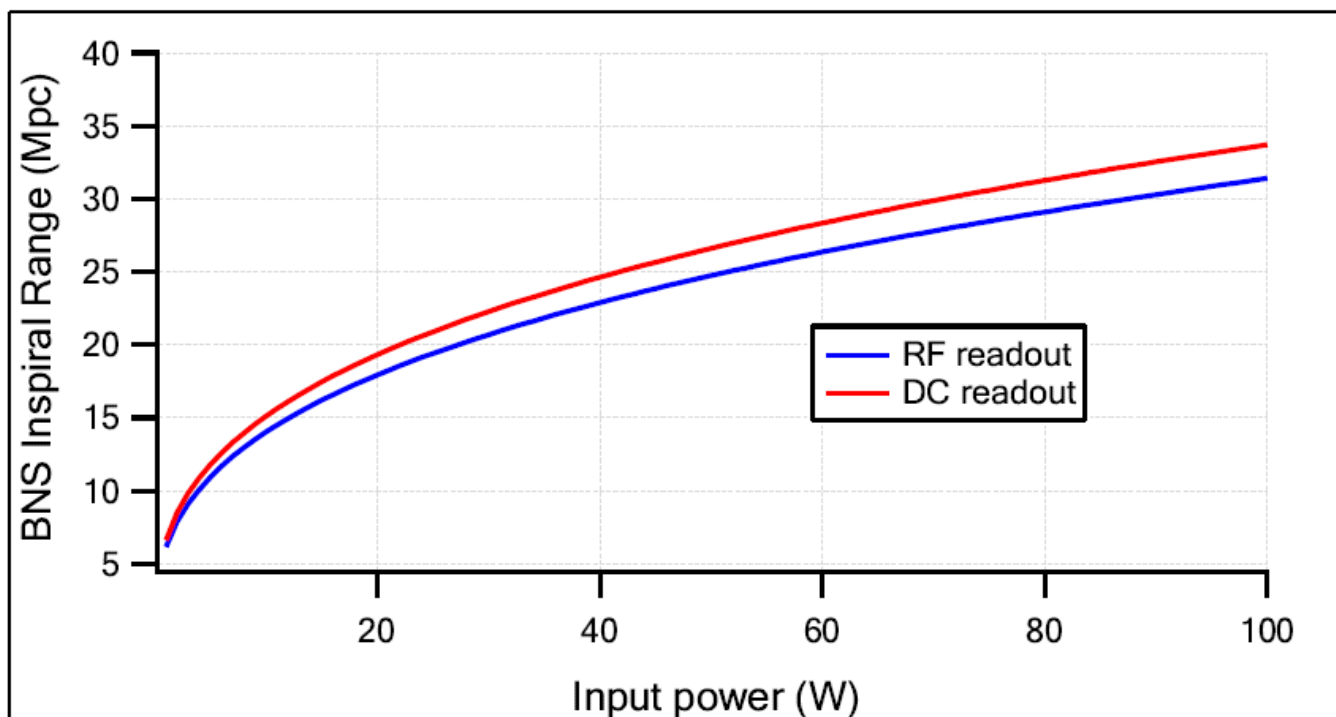
Let us assume 30kg mass (ϕ 30cm x 20cm) and calculate the sensitivity

iLCGT design



- Entirely dominated by seismic and shot noise
- Suspension material could be steel with $Q=1e5$
- $IR=18\text{Mpc}$ with 20W laser

iLCGT inspiral range vs power



- eLIGO IR is about 30Mpc with LCGT definition
- We won't reach that level but may come close
- Reduction of practical noise is rather essential

Summary and discussions

- **Current design is not the final design of LCGT**
- **Number of things should be checked**
- **Number of things should be determined**
- **How can we determine the things?**
- **Risk management is important**
- **We don't have too much time**