ERSE and LSRC for KAGRA+

2020.11.17
KAGRA-OzGrav Joint Meeting

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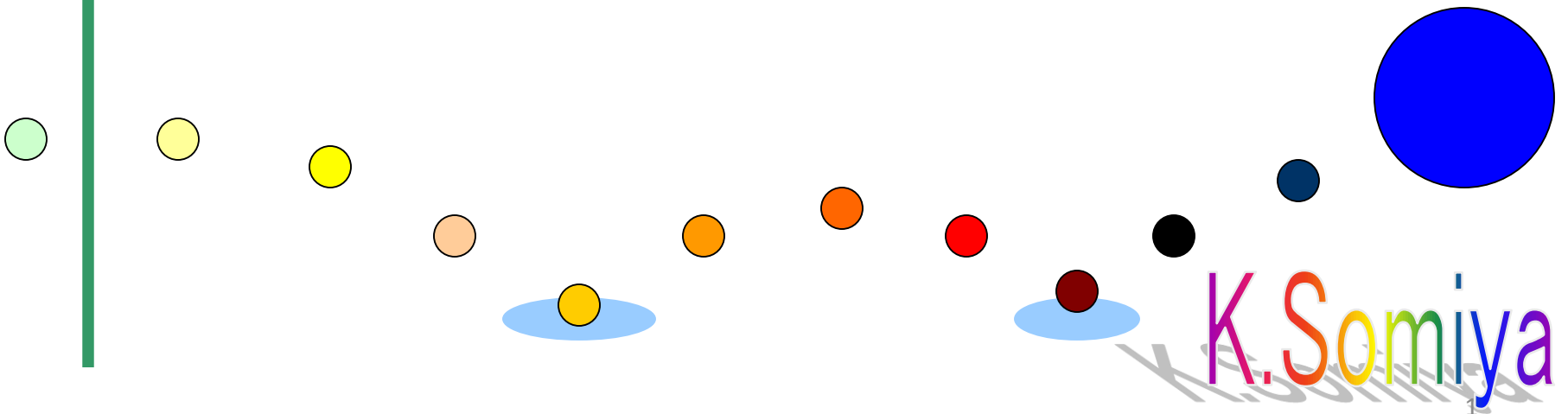
Heat absorption at the KAGRA ITM
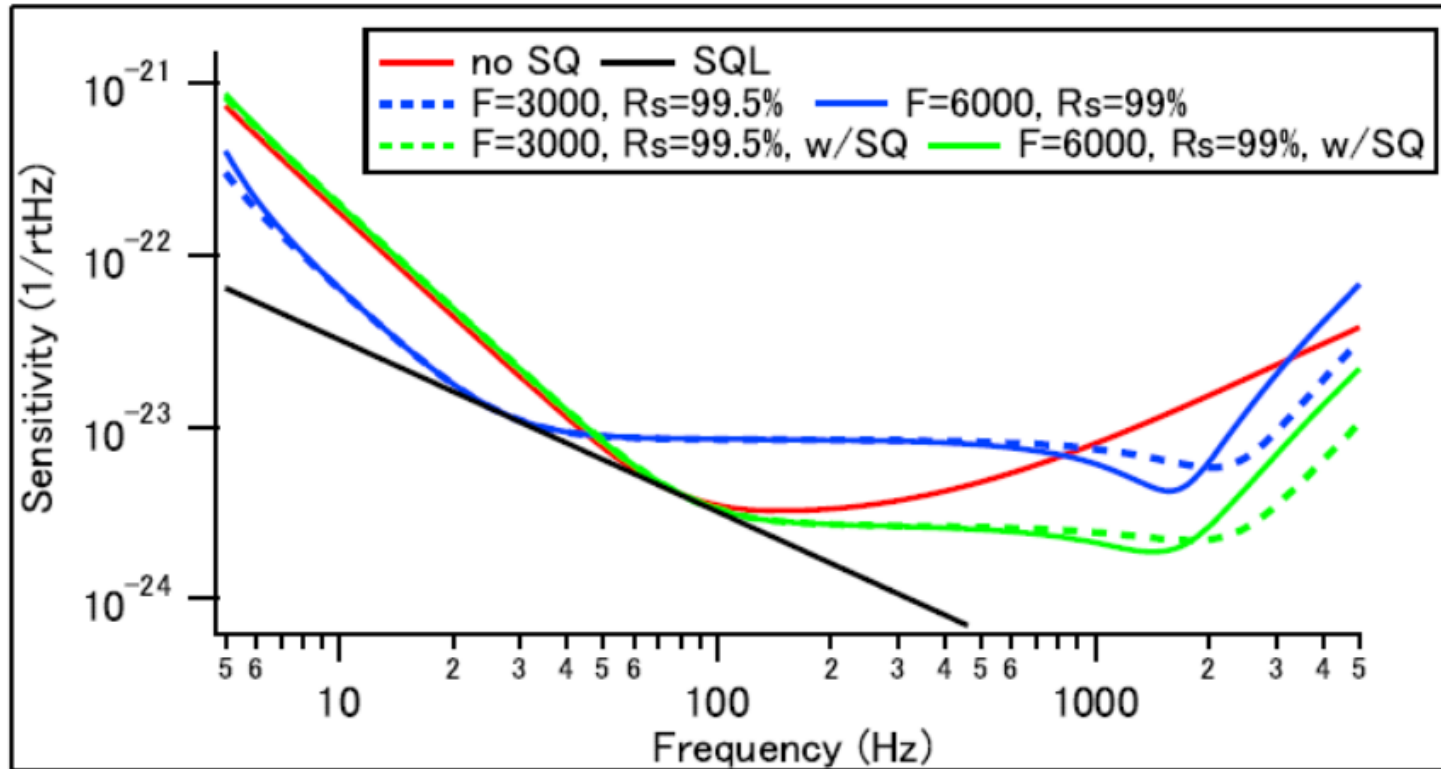
~1W

400kW

400W

F=1550

15cm
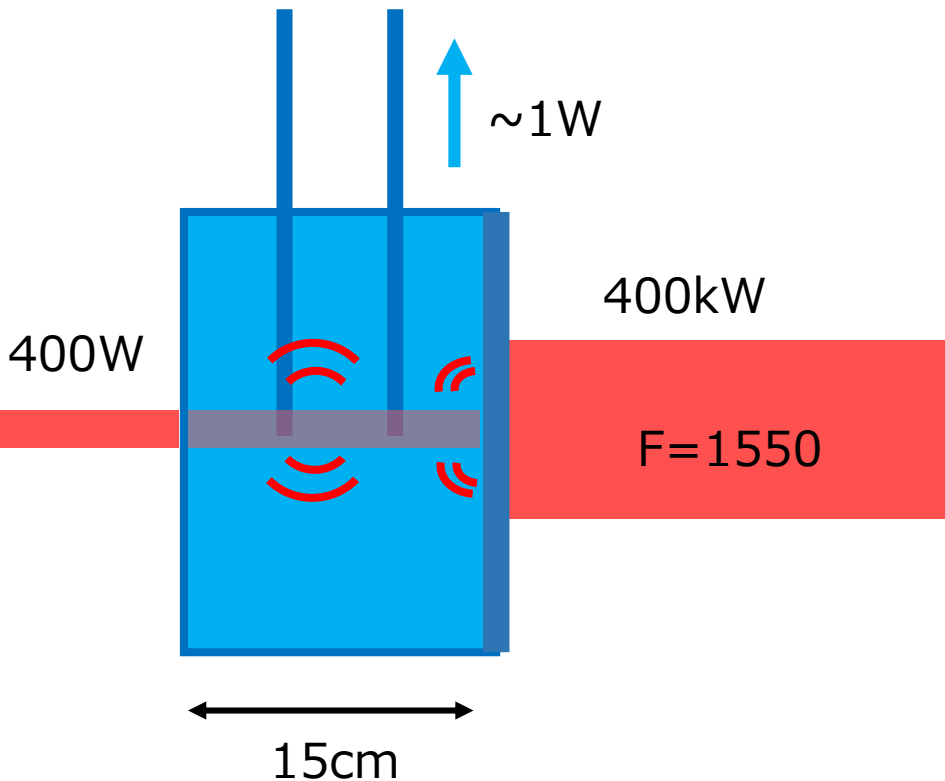
- Sub. absorption = 50ppm/cm → 0.6W
- Coat. absorption = 1.0ppm → 0.4W

- Cooling capability = 1W

We can accommodate twice as much power in the arm cavity if we increase the finesse by a factor of 6.

If we further increase the finesse a little more, we can omit the power recycling, or make it "extreme RSE" (ERSE).
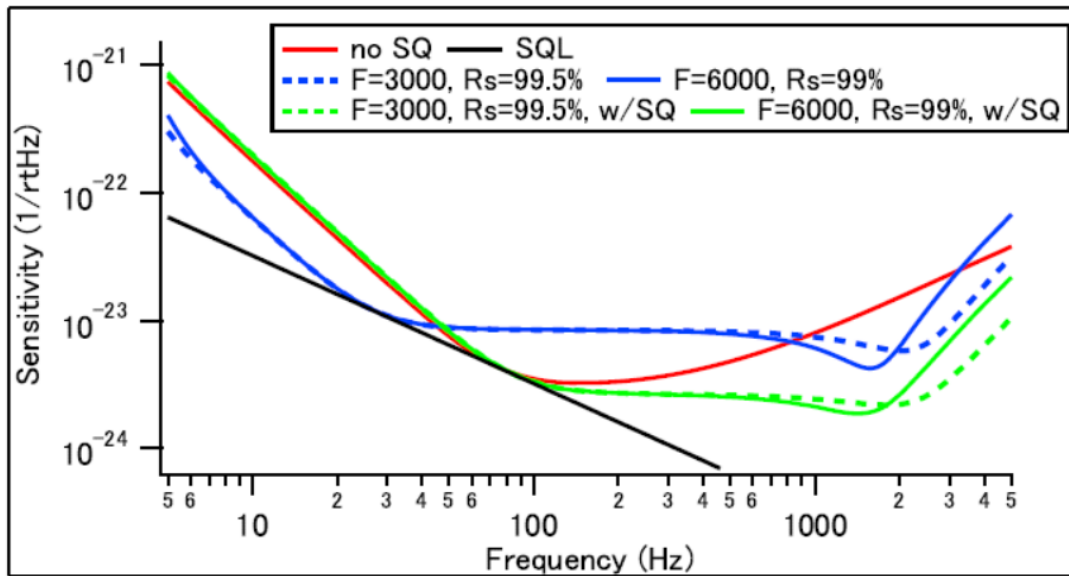
Long SRC effect

With such a high finesse, the sensitivity dip at a few kHz can be realized using the SRM of R=99% (long SRC effect).

* Here a 100ppm loss per bounce in the arm is included.
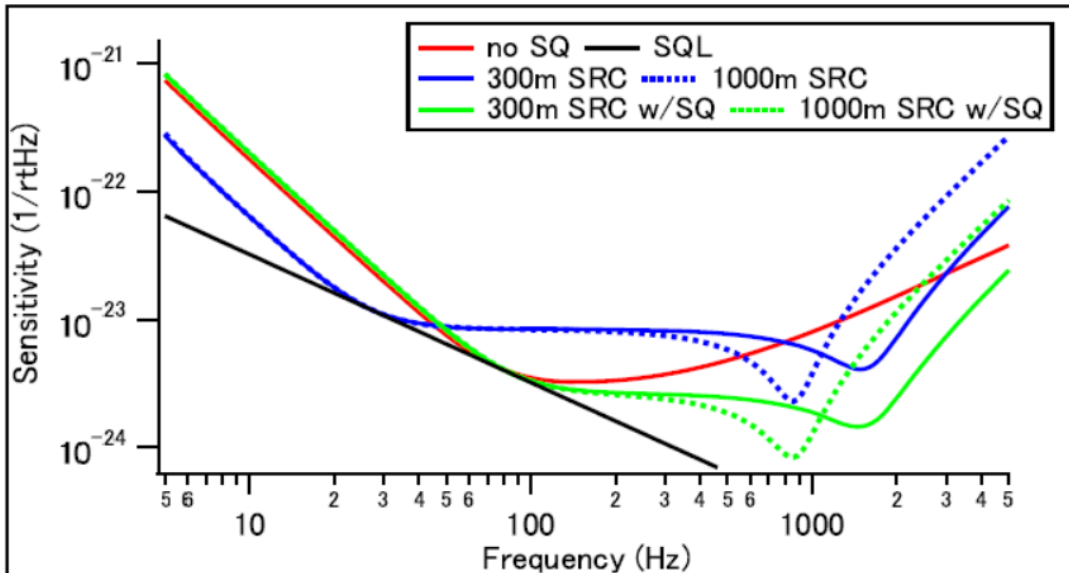*** The SRC length is 66.6m.**
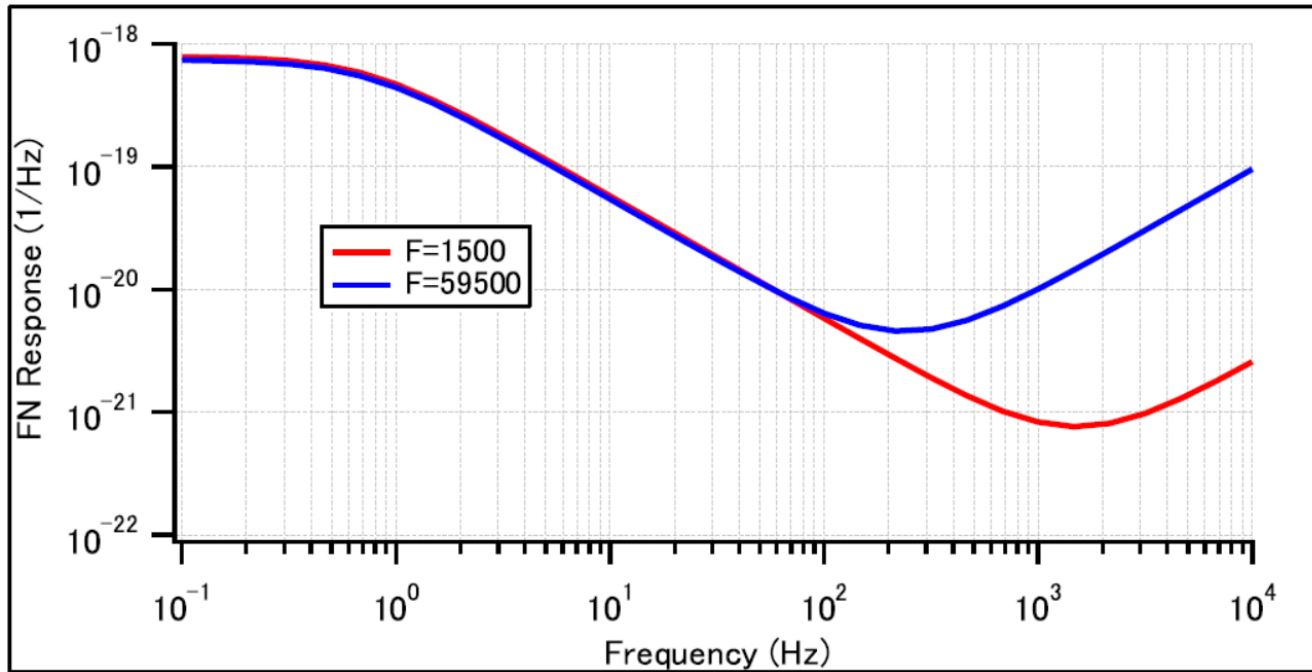
Long SRC effect

Comparison of the long SRC effect.

Top: high finesse, L=66m
Bot: current finesse, long L

The QN spectra in the blue solid line look identical. The loss influence is not negligible with squeezing (frequency independent).
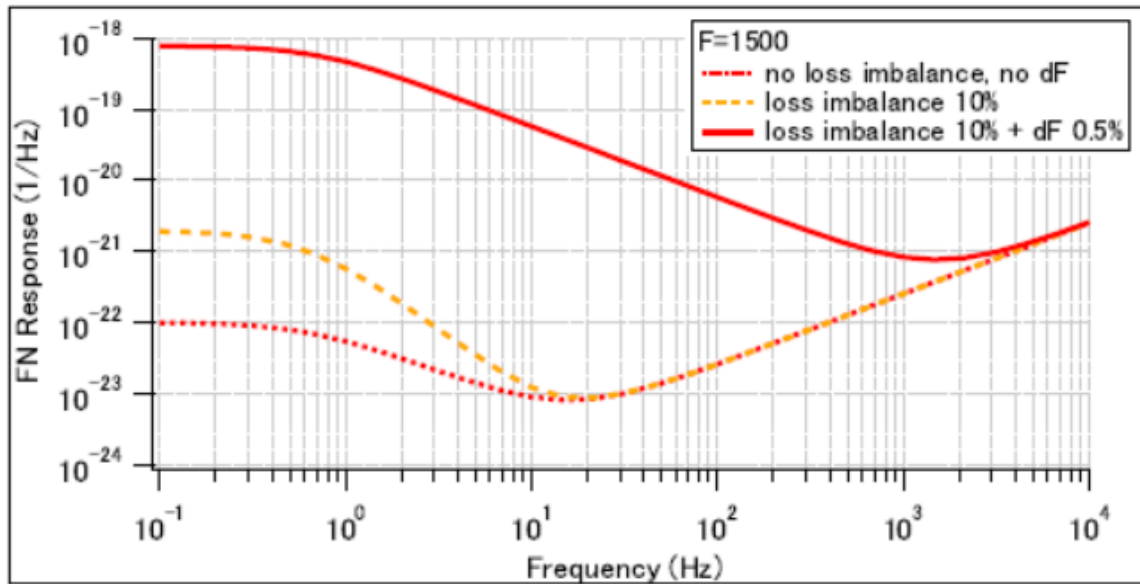
Frequency noise in ERSE

As was discussed 20 years ago when LIGO started planning the RSE, frequency noise coupling increases with the arm cavity finesse.
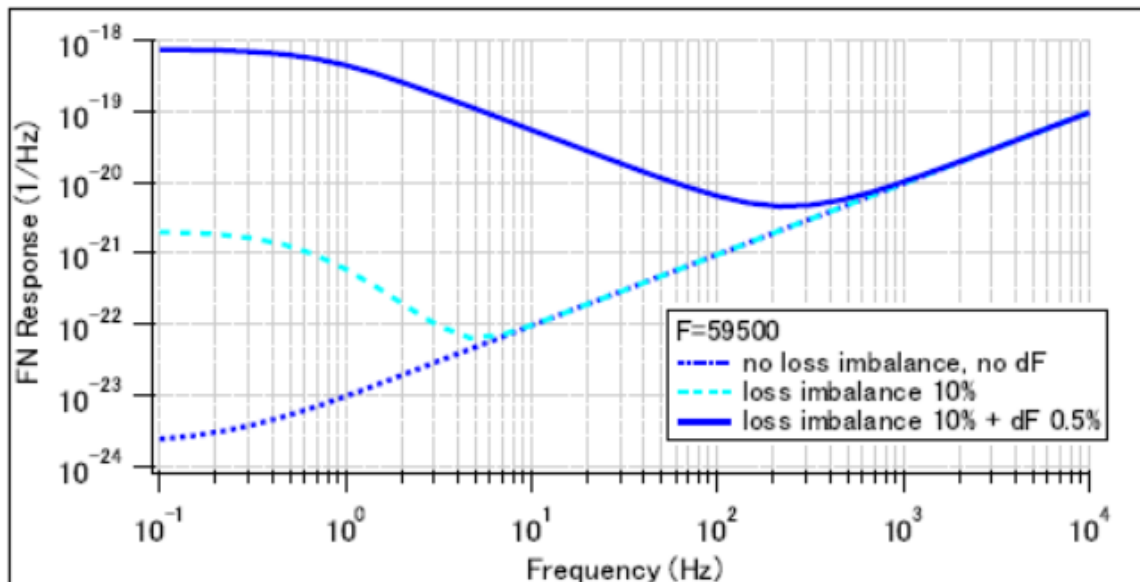
Here we included 10% loss imbalance and 0.5% finesse difference in the two arms.
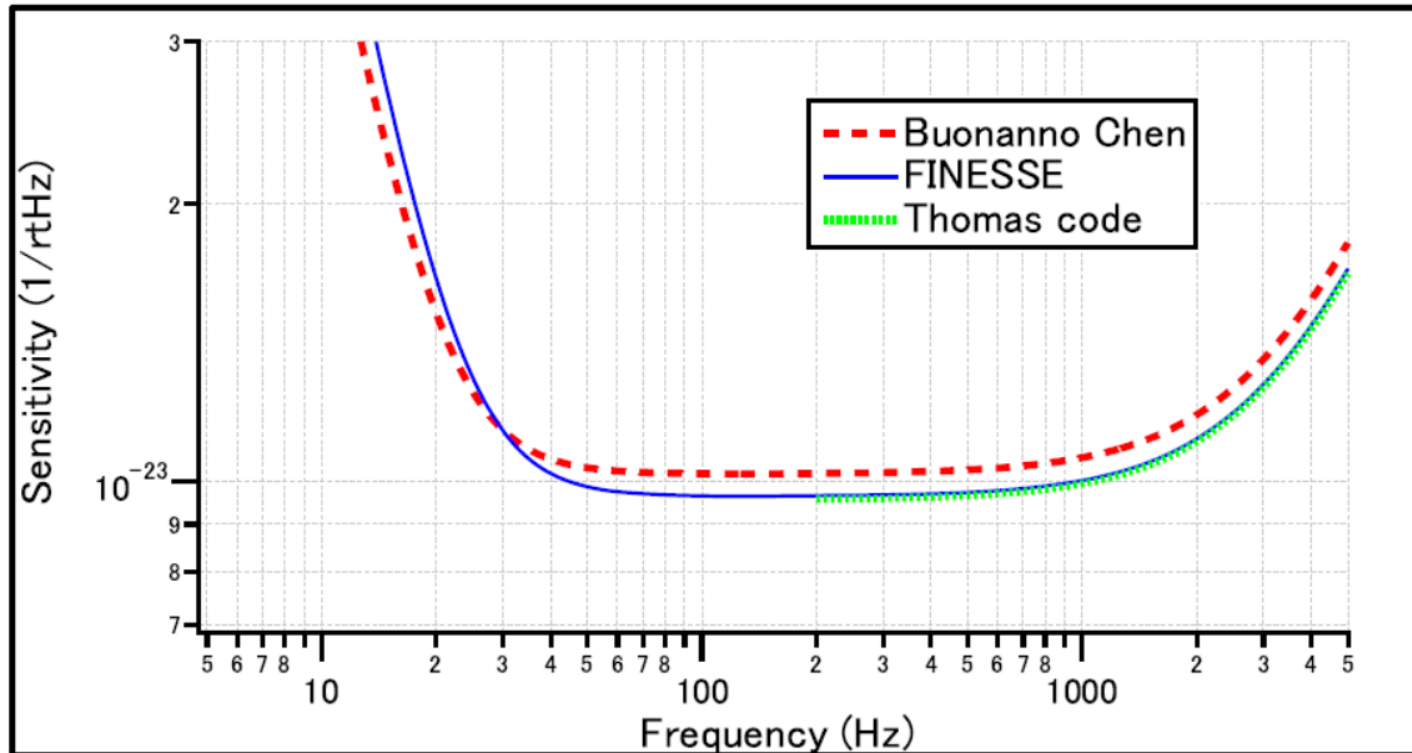
Frequency noise in ERSE

Actually, the difference does not come from the loss imbalance or finesse imbalance but from the Schnupp asymmetry.

Any imbalance in the central interferometer makes a non-trivial contribution in the frequency noise coupling.

Sapphire substrate inhomogeneity can lead to a significant increase of freq noise in ERSE.

Some notes

We have found some inconsistency between the simulation results and analytical results (Kimble or BC) in the case with very high finesse arm cavities. All the results shown in the slides are calculated with FINESSE.

<u>Summary</u>

- **Extreme RSE has been considered as an option for KAGRA+ to go to HF with increasing the intracavity power.**

- **Long SRC effect can be utilized with the ERSE.**

- **Increase of the frequency noise coupling through an imbalance of the ITM substrates can be an issue.**

- **Inconsistency of the quantum noise level between the numerical simulation and analytical calculation is an issue for the discussion.**