

On the effect of arm cavity finesse asymmetry to O3 sensitivity

Yutaro Enomoto

Kentaro Somiya

Yuta Michimura

Background

- Transmission measured to be
ITMX: 0.444 % ITMY: 0.479% ([JGW-T1809173](#))
- So the asymmetry was 0.076 although MIF requirement was $2 \cdot |(T1-T2)/(T1+T2)| < 0.01$ ([wiki](#))
- Arm cavity finesse recently measured to be
Xarm 1440(10) at cryo 1411(2) at room temp.
klog [9215](#), [9156](#), [9097](#), [9052](#), [9033](#), [9014](#), [8999](#) and [7307](#)
Yarm 1300(20) at cryo
klog [9211](#), [9169](#), [9052](#), [9047](#), [9040](#), [9023](#), [9014](#), [8995](#)
- ITMs also have inhomogeneity issues as studied in, for example, [JGW-G1909955](#)

Finesse and ITM transmission

- Xarm 1440(10) [1411(2)] means
ITMX transmission + losses = 0.436(3) %
0.444 % according to [JGW-T1809173](#) [0.445(1) %]
- Yarm 1300(20) means
ITMY transmission + losses = 0.483(7) %
0.479 % according to [JGW-T1809173](#)
- Yarm sounds reasonable but Xarm finesse seems to be too high
 - could be due to finesse measurement at cryogenic temperatures
 - could be due to some systematic errors

Effects of Finesse Asymmetry

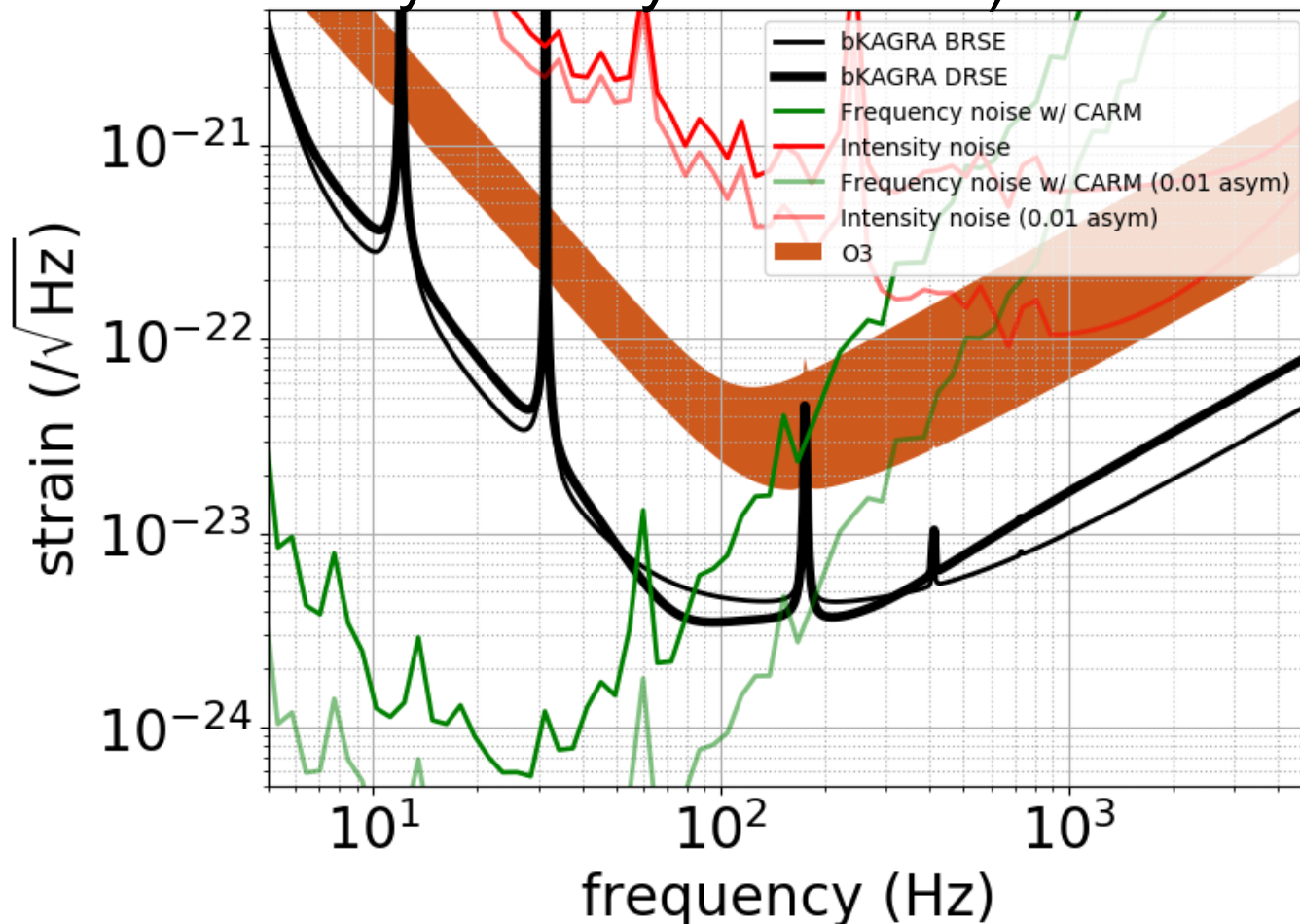
- Larger laser frequency noise
 - Larger laser intensity noise
 - These effects are presented below
-
- Note that these effects will be even larger with ITM inhomogeneity
 - With ITM inhomogeneity, shot noise will be worse due to larger HOMs but the effect would be small (~14 % increase according to [JGW-G1909955](#))

Method for Calculations

- Simulate frequency/intensity noise coupling with Optickle ([JGW-T1910341](#))
 - Note that it gives transfer function from laser frequency noise **without** CARM suppression to strain sensitivity (CARM openloop gain assumed)
 - Used power at BS 10 W, ITMX 0.44% ITMY 0.479 % case (ITMX 0.44% ITMY 0.4445% as comparison)
- Multiply the coupling factor to frequency noise and intensity noise of IMC transmitted beam
 - frequency noise: 1 Hz/rtHz @ 100 Hz ([klog #9291](#))
 - intensity noise: $2e-5$ /rtHz @ 100 Hz **without** intensity stabilization ([klog #9259](#))

Results

- Intensity noise **not OK**. Frequency noise at high frequencies **not OK** (but cannot be resolved even if ITM asymmetry was 0.01)



Intensity noise with stabilization to be measured soon

With frequency noise, O3 inspiral range will be 7-18 Mpc instead of 8-24 Mpc

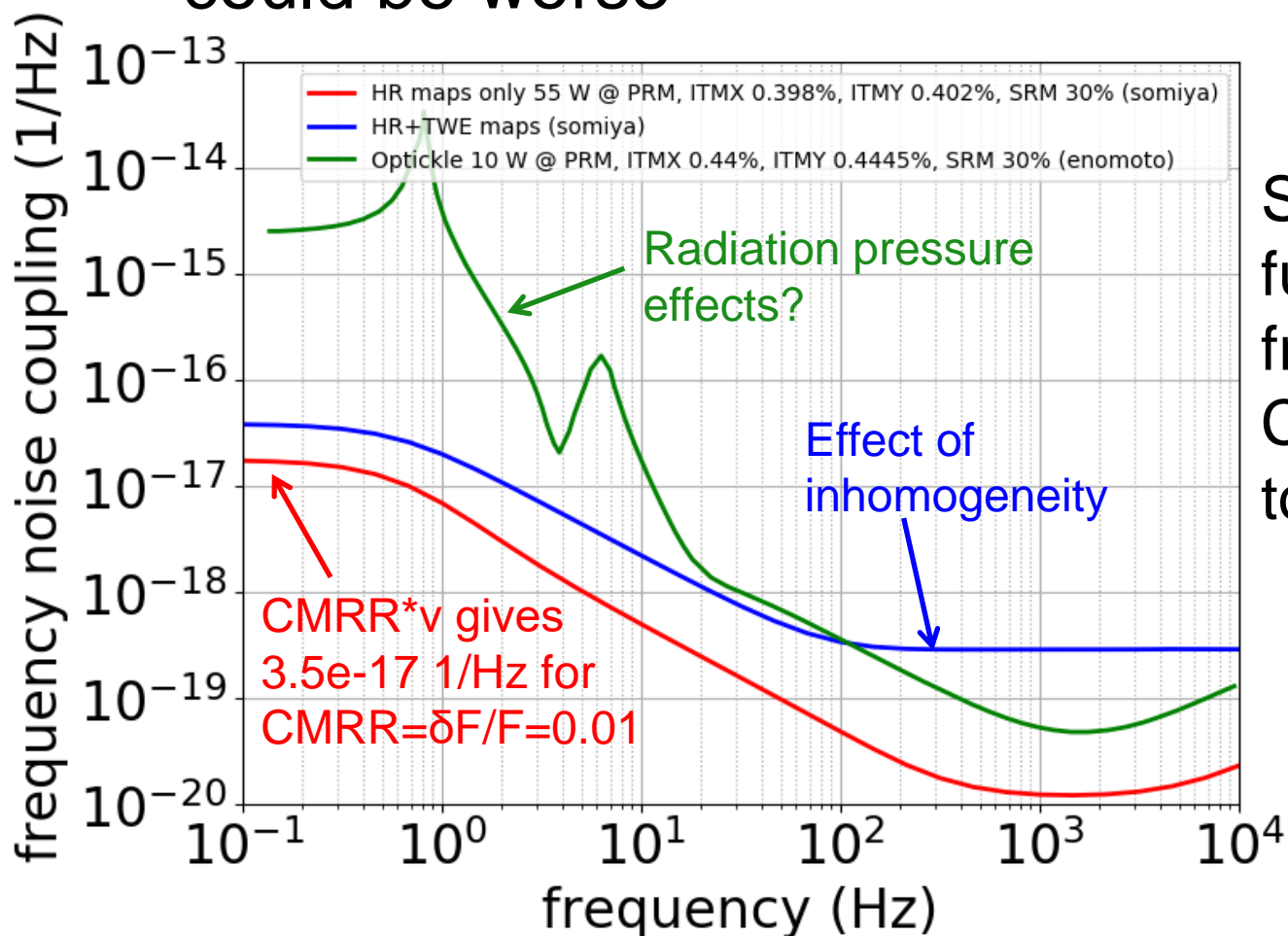
Conclusions

- Measured arm cavity finesse asymmetry can be basically explained by ITM transmission asymmetry but we cannot say that ITM transmission asymmetry is the only reason
- We cannot say much if current finesse asymmetry is acceptable for O3 or not since frequency noise and intensity noise is bad at this moment.
- Frequency noise do not meet the O3 requirement at high frequencies. We should identify the noise at high frequencies and try to reduce it.
- Intensity noise without stabilization do not meet the O3 requirement. We need to wait for the stabilization result.
- This finesse asymmetry and ITM inhomogeneity will likely to be an issue for achieving the design sensitivity.

Some More Details

Optickle vs FINESSE

- Optickle calculation do not include ITM HR maps and inhomogeneity; Frequency noise coupling could be worse

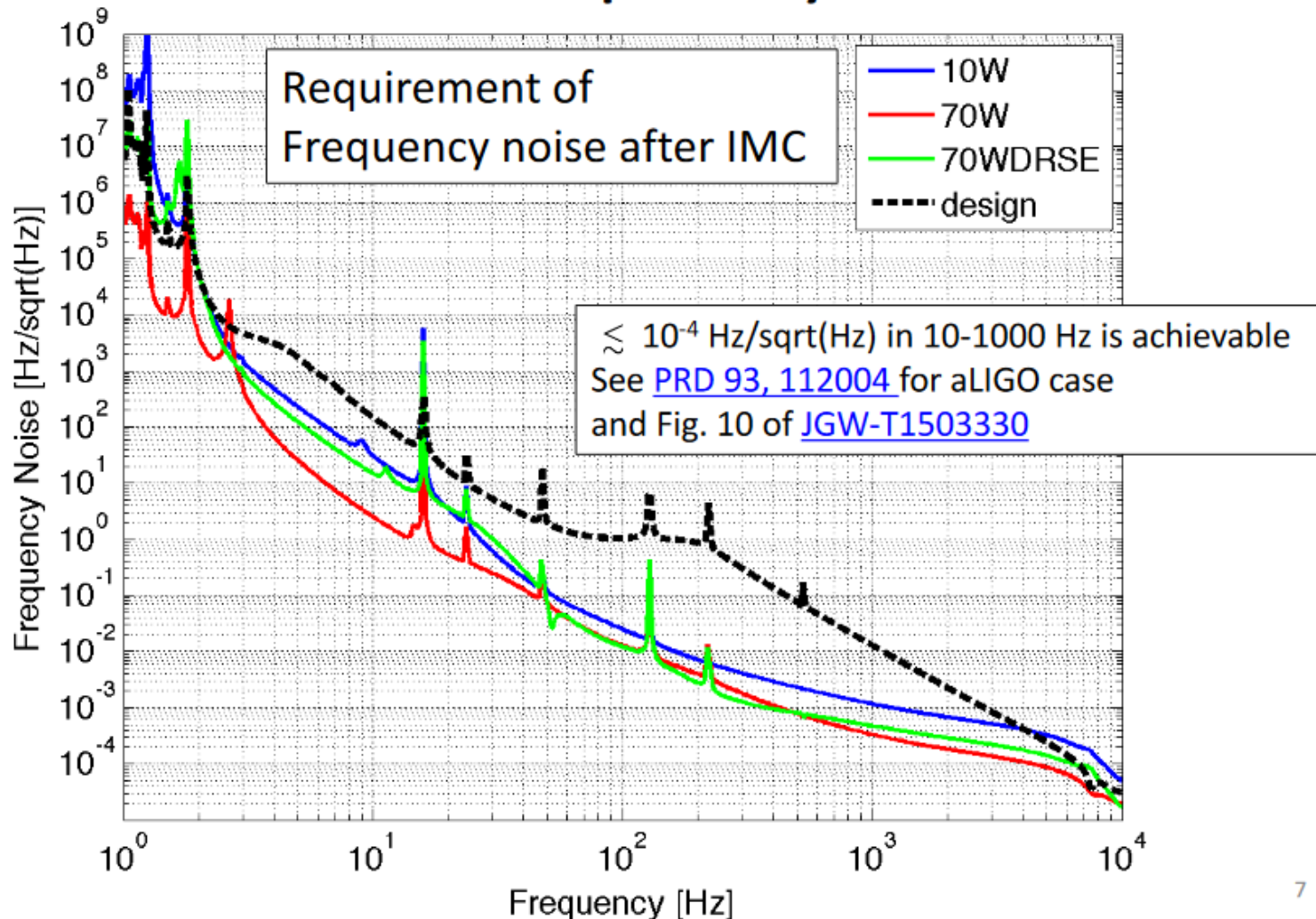


Simulated transfer functions from frequency noise **with** CARM suppression to strain sensitivity

Frequency Noise Requirements

- See [JGW-T1707565](#) (ITM 0.4% and 0.5%, SRM 30%)

Results: Frequency noise



Frequency Noise Requirements

- Compared with measurements ([klog #9256](#))

Results: Frequency noise

