

Discussion on Interferometer Configuration for O4

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Executive Summary

- Hmm

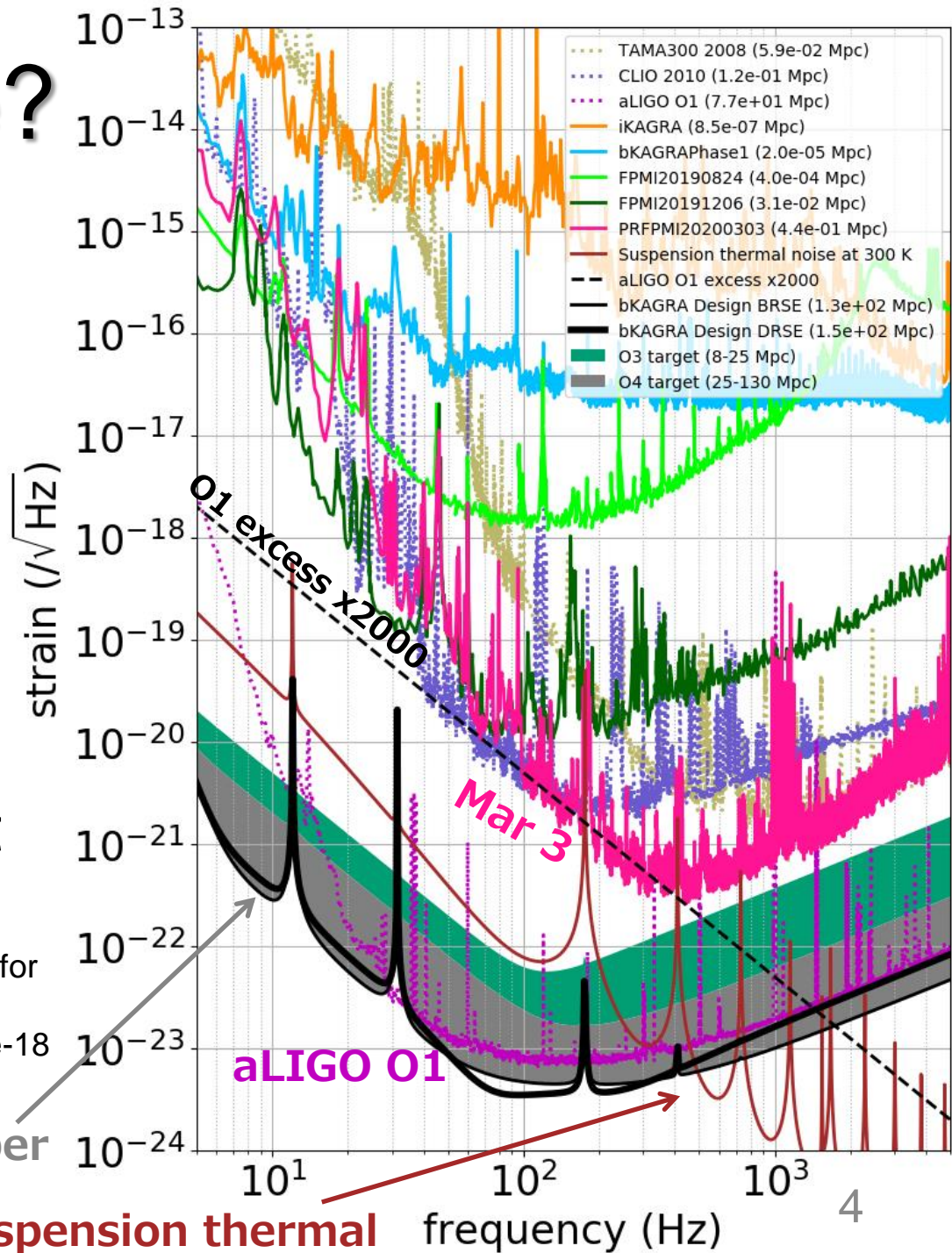
List of Considerations

- **Cryogenic** temperature necessary?
 - Depends on sensitivity necessary
- Which **SRM reflectivity**?
 - 0 % or 70 % or 85 %
 - Depends on feasibility of DR locking
- **Polarizers** in PRC and SRC necessary?
 - Depends on birefringence effect to sidebands
 - See [JGW-T1910396](#) for proposal
- **ITM recoating** necessary?
 - Depends on the effect of transmission asymmetry to CMRR of frequency/intensity noise

Where Are We?

- 400-500 kpc
- PRFPMI with 70% SRM tilted, 3-5 W to PRM, ~240 K, DC readout
- O1 excess x2000 !
- Pretty close to shot noise ([klog #13144](#))?

([klog #12772](#) gives $6e-18$ m/rtHz @ 1 kHz for 1.4 W input, 3.4 mW at OMC PDA. 4.5 W input, 8 mW at OMC PDA should give $\sim 2e-18$ m/rtHz for current setup.)



O4 target on Obs. Scenario Paper
25-130 Mpc by ~2021

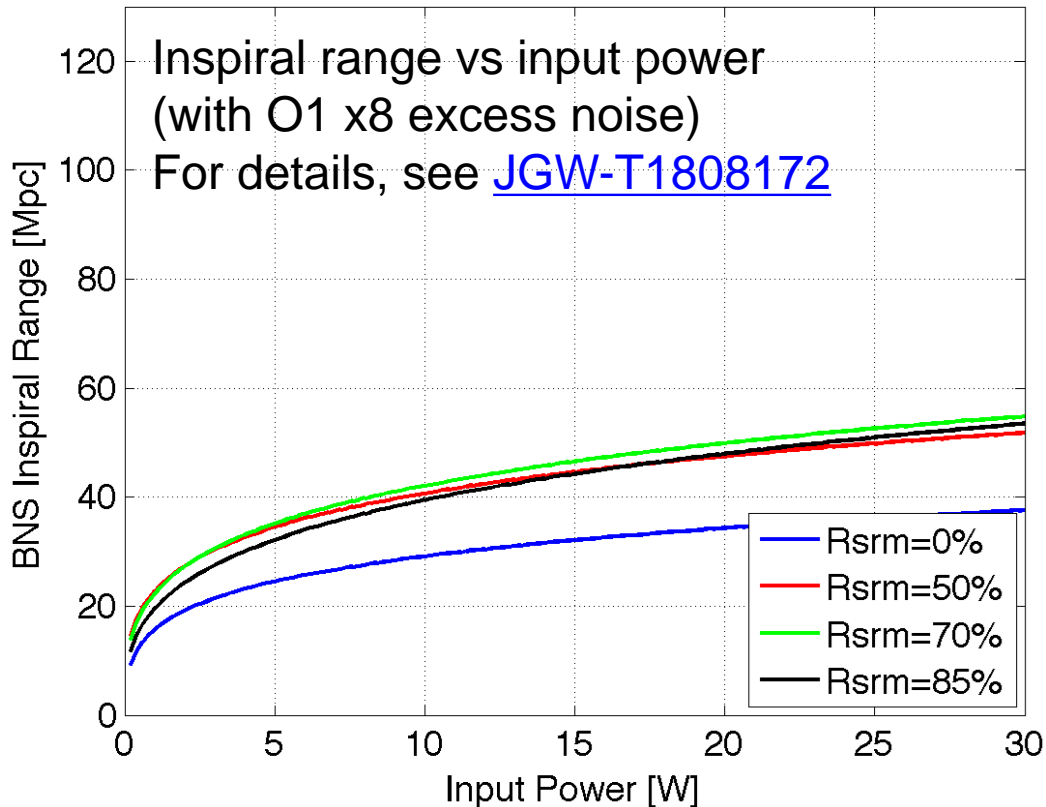
Current Status and O4 Target

- Cryogenic necessary for sure

	Mirror temp.	Power at BS	SRM reflectivity	Detuning angle	Homodyne angle	Excess noise
NOW	~240 K	30-50 W	70% tilted	~90 deg (PRFPMI)	~90 deg (conventional)	O1 x 2000
O3 low	22 K	10 W	0 %	90 deg (PRFPMI)	90 deg (conventional)	O1 x 20
O3-15Mpc	22 K	10 W	70 %	90 deg	90 deg	O1 x12
O3 high / O4 low	22 K	33 W	70 %	90 deg (BRSE)	90 deg (conventional)	O1 x 8
O4 80Mpc	22 K	404 W	85 %	90 deg	90 deg	O1 x 2
O4 high	22 K	673 W	85 %	90 deg (BRSE)	90 deg (conventional)	no excess
Design	22 K	673 W	85 %	86.5 deg	135.1 deg	no excess

DR Necessary?

- **DR is better and almost necessary** (especially better when low frequency excess noise is too much)
- Still, **70% SRM seems good** for O4 (we don't have much confidence on higher power)



Feasibility of Locking DR

- According to Nakano-kun
 - DRMI on 1f is fine. Lasts 30 min or so
 - DRMI on 3f lasts 5 min or so [klog #12535](#)
- Needs more time (~ a week?) to assess if DRFPMI is feasible or not with current ITMs
- If not feasible, our choice for O4 will be
 - Go with PRFPMI, install 0% SRM
 - Evaluate if polarizers in PRC and SRC will help locking DRFPMI

Effect of T_ITM asymmetry

- See [JGW-T1910352](#)
- Considering frequency noise and intensity noise coupling, achieving the designed sensitivity is not feasible, but achieving O4 target (25-130 Mpc) should be possible with current ITM transmission asymmetry (if inhomogeneity effect is not considered)
- **Re-coating is not necessary for O4**
- **Need to evaluate the effect of inhomogeneity with current setup**

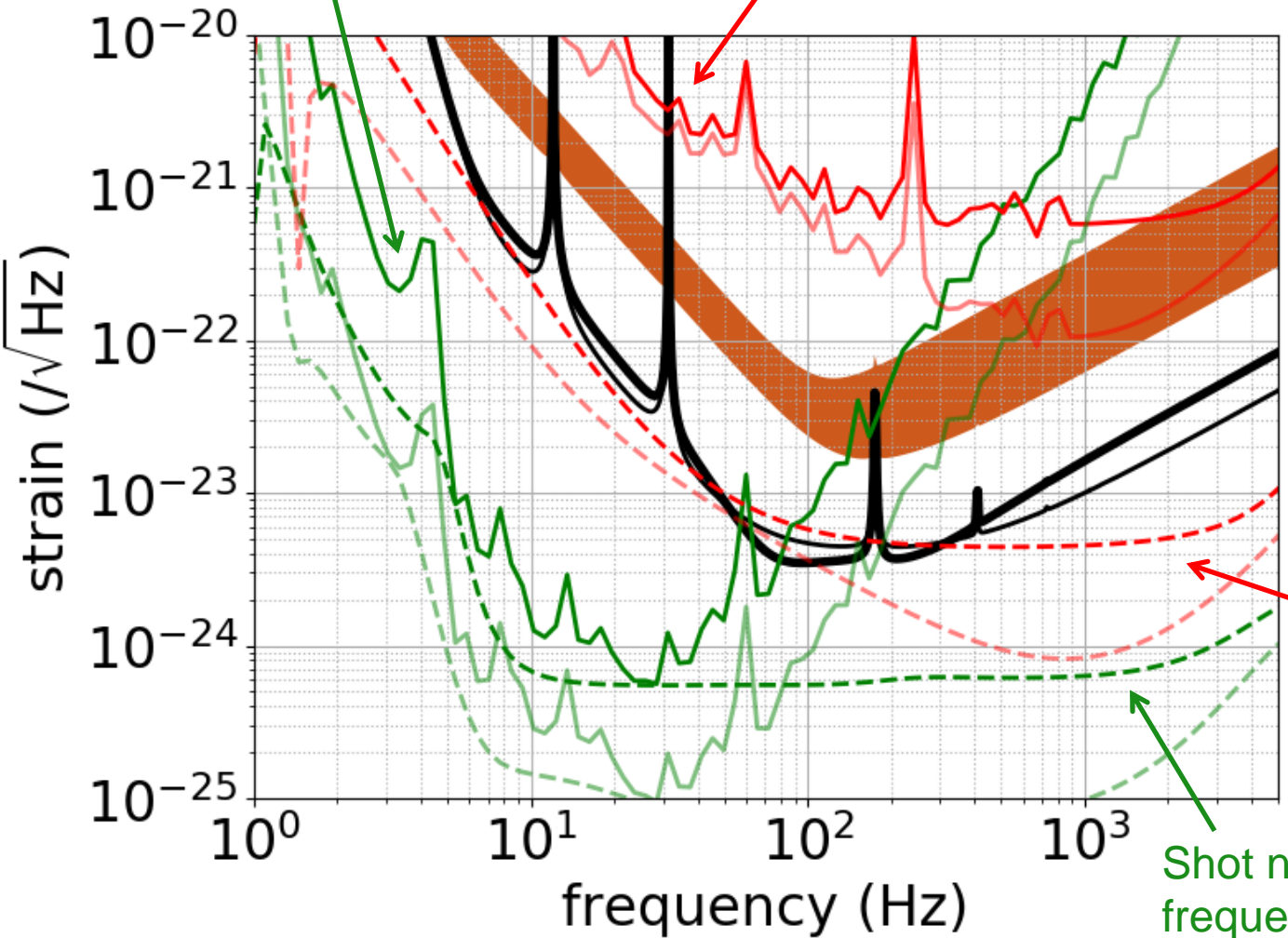
Frequency noise coupling estimated with current measured frequency noise; CARM loop turned on (could be limited by measurement noise at high frequencies)

Result

Copied from [JGW-T1910352](#)

Dim lines represent same curves when ITM transmission asymmetry was 0.01

Intensity noise coupling estimated with current measured intensity noise (stabilization servo not on yet)



- bKAGRA BRSE
- bKAGRA DRSE
- Frequency noise w/ CARM
- - CARM shot noise
- Intensity noise
- - Intensity noise RIN 1e-7 /rtHz
- Frequency noise w/ CARM (ITM 0.01 asym)
- - CARM shot noise (ITM 0.01 asym)
- Intensity noise (ITM 0.01 asym)
- - Intensity noise RIN 1e-7 /rtHz (ITM 0.01 asym)
- O3

Intensity noise coupling when RIN = 1e-7 /rtHz (as was the case in klog #7177, after PSL 1st-loop)

Shot noise limit of frequency noise stabilization

Conclusions So Far

- **Cryogenic** temperature necessary?
 - Necessary to achieve O4 target (25-130 Mpc)
- Which **SRM reflectivity**?
 - DR is better but we have to assess if DR locking is feasible or not
 - If DR is feasible, 70% SRM is good
- **Polarizers** in PRC and SRC necessary?
 - We need to assess if DR locking is feasible without polarizers
- **ITM recoating** necessary?
 - Recoating is not necessary but we should estimate the effect of inhomogeneity

List of Measurements to be Done

- Feasibility of locking DRFPMI (~ 1 week)
- Shot noise calculation (~ 0.5 day)
- Power recycling gain for sidebands (~ 0.5 day)
- LSC and ASC sensing matrix (~ 2 days)
- MICH/PRCL/SRCL to DARM coupling (~ 1 day)
- Frequency and intensity noise coupling (~ 1 day)
- MICH contrast defect with MICH locked and FPMI locked (~ 1 day)
- Mode content of AS (OMC cavity scan) (~ 0.5 day)
- Scattered light investigations (~ 1 week)
- Compare measurements with Optickle/FINESSE simulations