

# Discussion on Interferometer Configuration for O4

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# Executive Summary

- Hmm

# List of Considerations

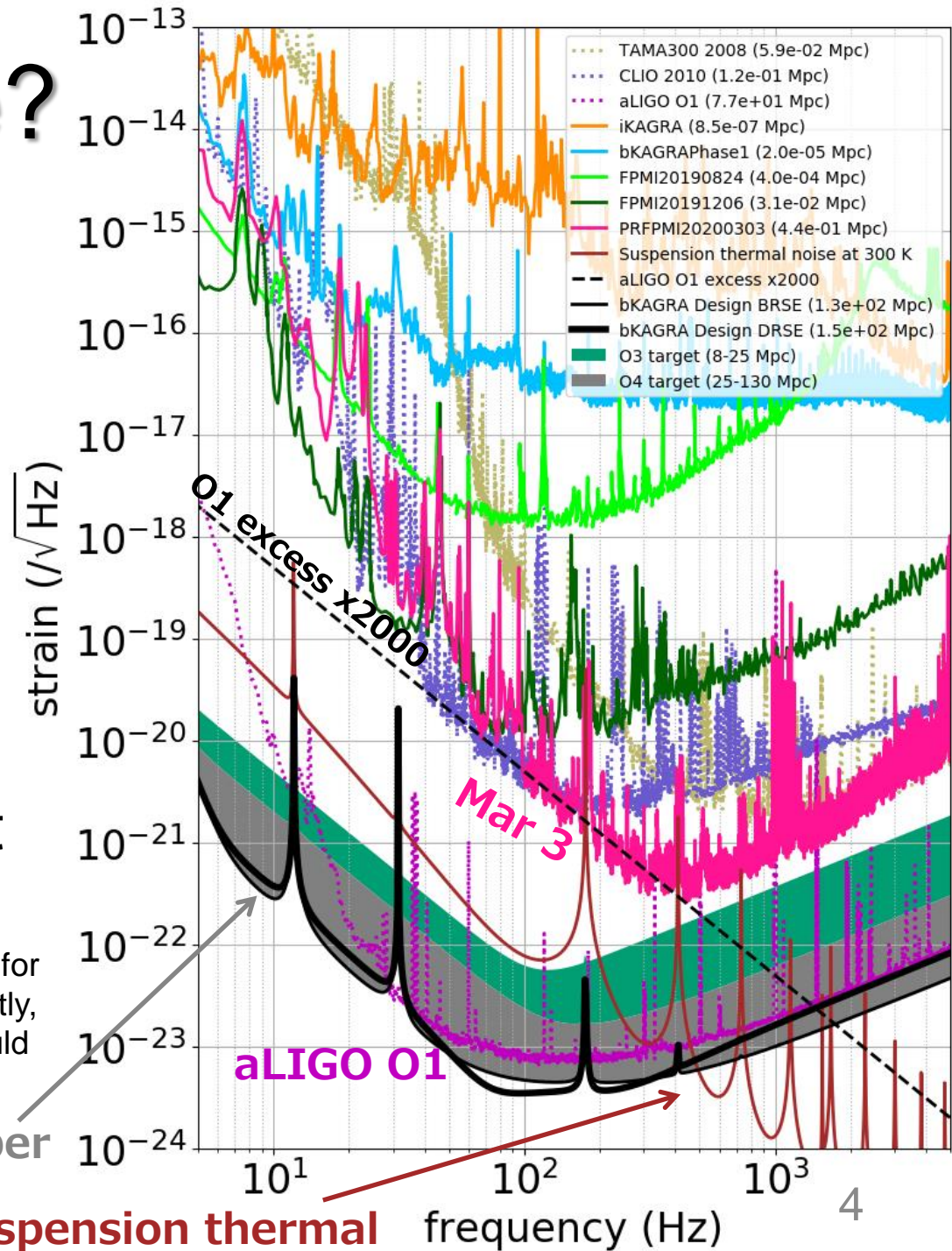
- **Cryogenic** temperature necessary?
  - Depends on sensitivity necessary
- Which **SRM reflectivity**?
  - 0 % or 70 % or 85 %
  - Depends on feasibility of DR locking
- **Polarizers** in PRC and SRC necessary?
  - Depends on birefringence effect to sidebands
  - See [JGW-T1910396](#) for proposal
- **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. Currently, ~3 W input, 8 mW at OMC PDA. This should give ~ $3e-18$  m/rtHz for current setup.)

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



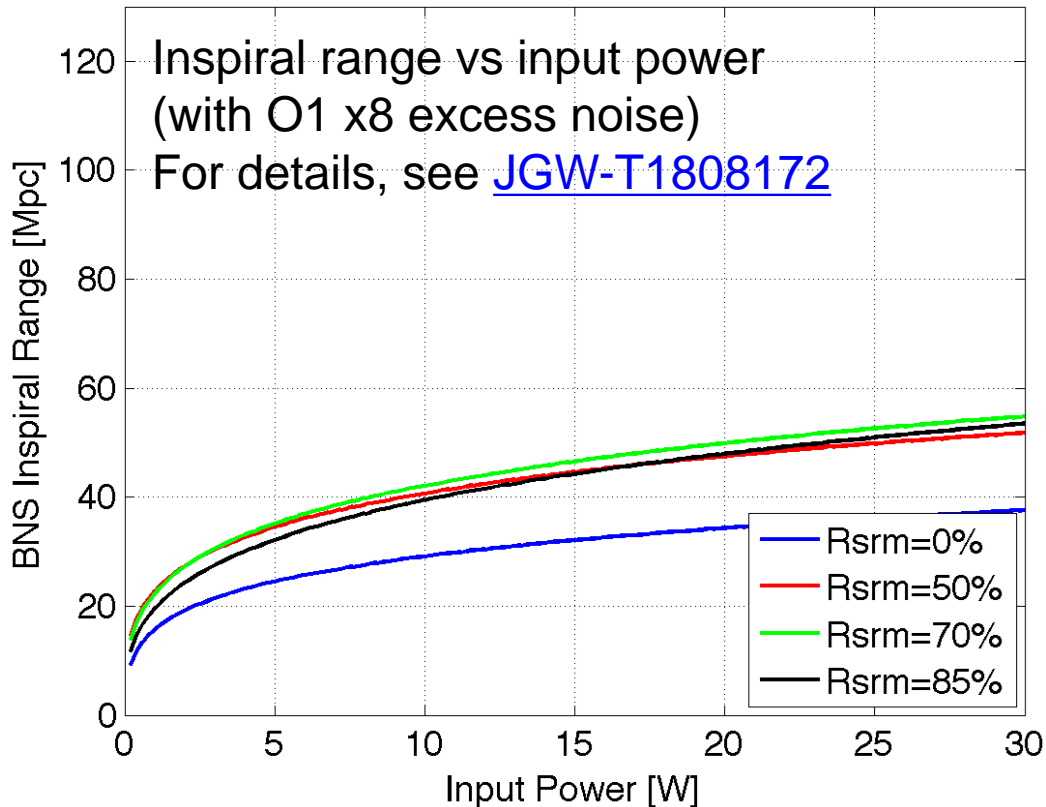
# Current Status and O4 Target

- Cryogenic necessary for sure

	Mirror temp.	Power at BS	SRM reflectivity	Detuning angle	Homodyne angle	Excess noise
<b>NOW</b>	<b>~240 K</b>	<b>30-50 W</b>	<b>70% tilted</b>	<b>~90 deg (PRFPMI)</b>	<b>~90 deg (conventional)</b>	<b>O1 x 2000</b>
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**



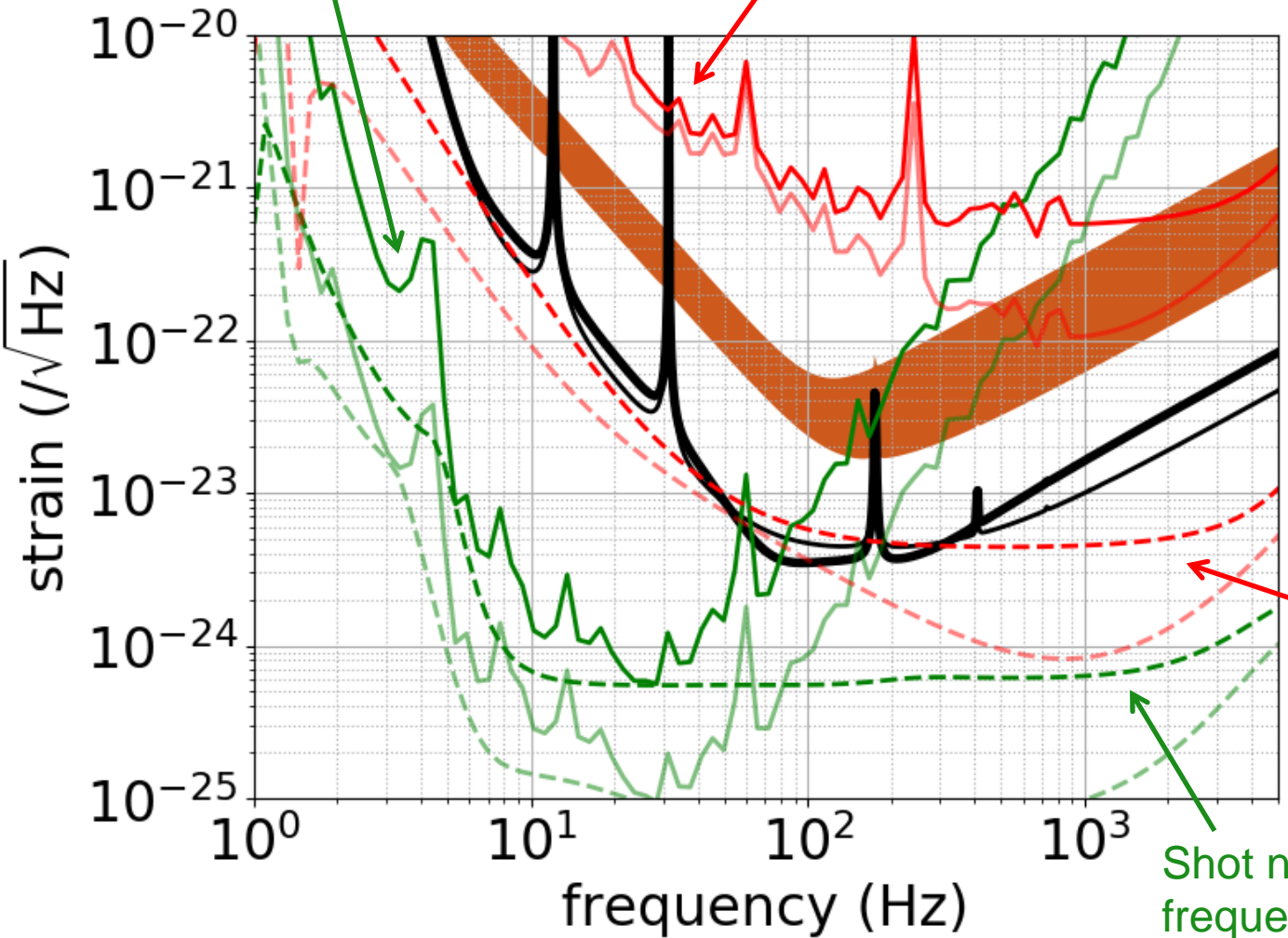
Frequency noise coupling estimated with current measured frequency noise; CARM loop turned on (could be limited by measurement noise at high frequencies)

# 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)
- 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 them with Optickle/FINESSE simulations