

O3 Estimated Sensitivity for FPMI, PRFPMI and RSE

Yutaro Enomoto, Yuta Michimura

Department of Physics, University of Tokyo

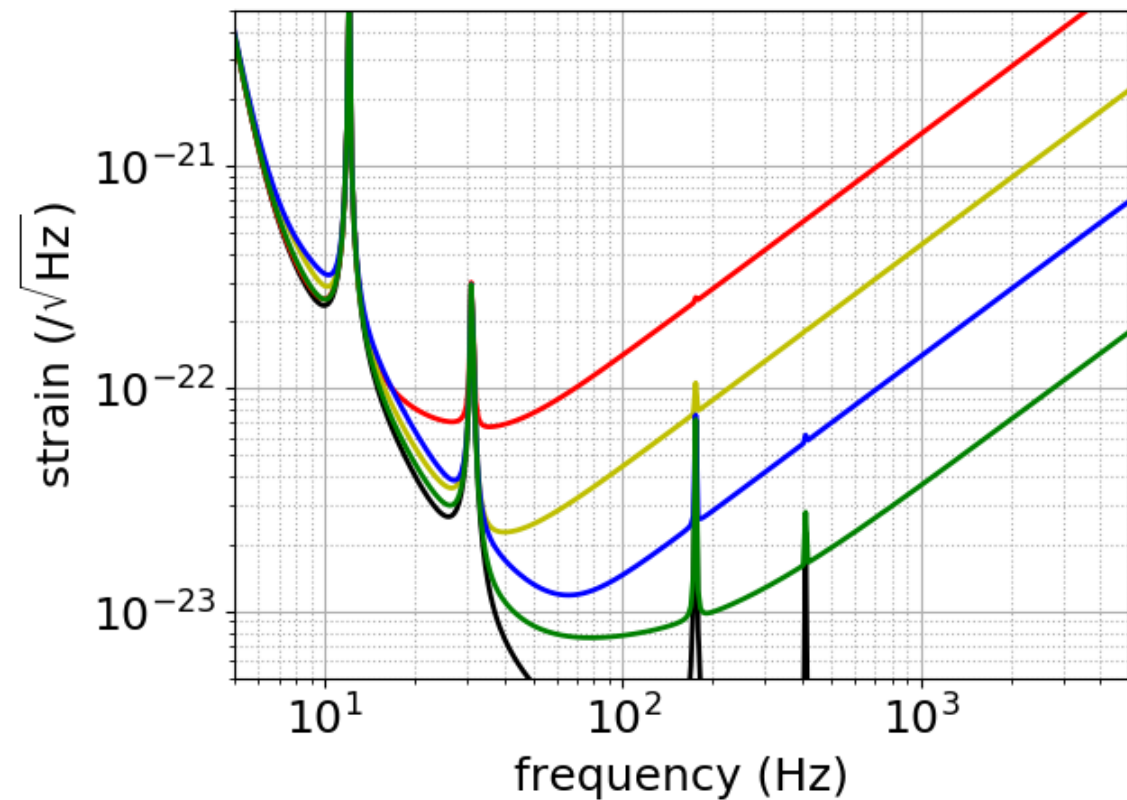
Kentaro Somiya

Department of Physics, Tokyo Institute of Technology

Conditions

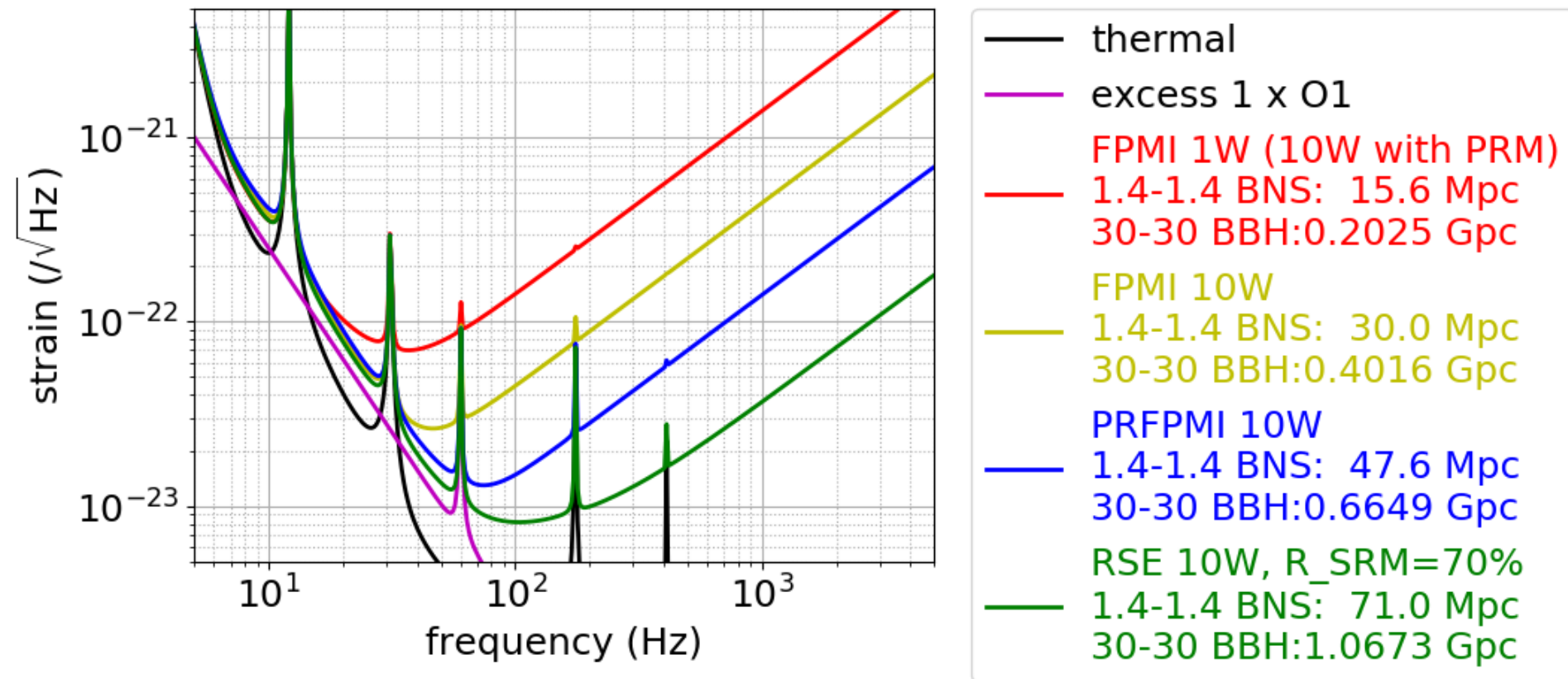
- 10W input
- Shot noise coupling with feedforward gain 100 included
- Four IFO configurations
 - **FPMI with tilted PRM** (equivalent to 1W input power)
 - **FPMI with blank PRM**
 - **PRFPMI** ($R_SRM=0\%$)
 - **RSE with $R_SRM=70\%$**
- Four excess noise models
 - No excess
 - aLIGO O1 level
 - 4x aLIGO O1 level (AdV O2 level)
 - 8x aLIGO O1 level
- Suspension and mirror thermal noise at 22 K

Sensitivity with No Excess Noise

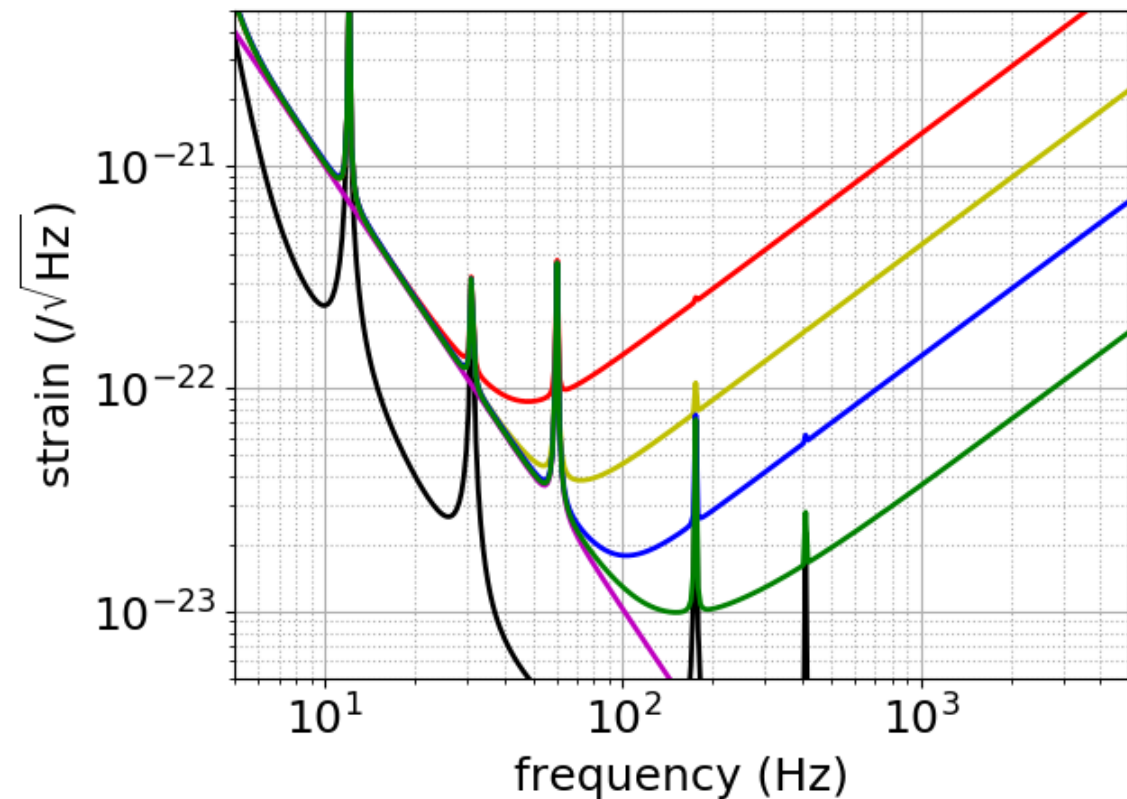


- thermal
- excess 0 x O1
- FPMI 1W (10W with PRM)
- 1.4-1.4 BNS: 18.0 Mpc
- 30-30 BBH: 0.2349 Gpc
- FPMI 10W
- 1.4-1.4 BNS: 36.7 Mpc
- 30-30 BBH: 0.4970 Gpc
- PRFPMI 10W
- 1.4-1.4 BNS: 57.9 Mpc
- 30-30 BBH: 0.8215 Gpc
- RSE 10W, R_SRM=70%
- 1.4-1.4 BNS: 93.4 Mpc
- 30-30 BBH: 1.4323 Gpc

Sensitivity with O1 Excess Noise

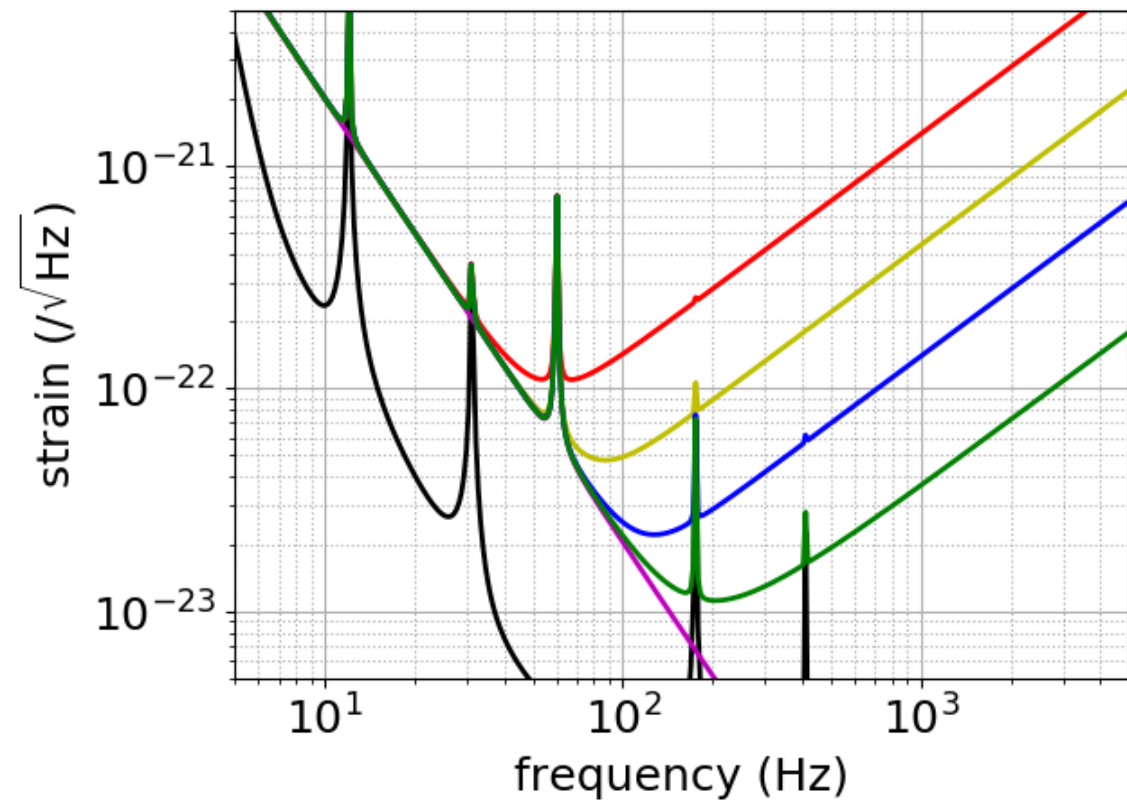


Sensitivity with x4 O1 Excess Noise



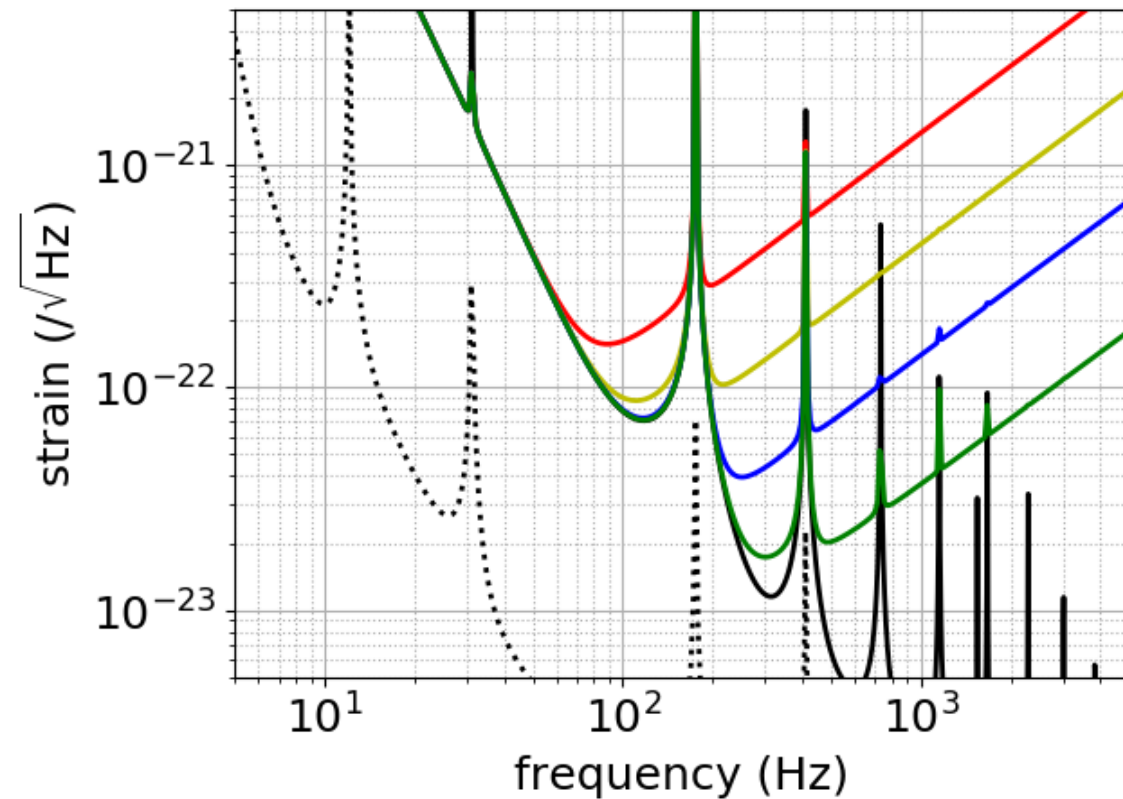
- thermal
- excess 4 x O1
- FPMI 1W (10W with PRM)
1.4-1.4 BNS: 9.5 Mpc
30-30 BBH: 0.1228 Gpc
- FPMI 10W
1.4-1.4 BNS: 16.3 Mpc
30-30 BBH: 0.2137 Gpc
- PRFPMI 10W
1.4-1.4 BNS: 27.1 Mpc
30-30 BBH: 0.3737 Gpc
- RSE 10W, R_SRM=70%
1.4-1.4 BNS: 41.6 Mpc
30-30 BBH: 0.6219 Gpc

Sensitivity with x8 O1 Excess Noise



- thermal
- excess 8 x O1
- FPMI 1W (10W with PRM)
- 1.4-1.4 BNS: 6.7 Mpc
- 30-30 BBH: 0.0859 Gpc
- FPMI 10W
- 1.4-1.4 BNS: 11.2 Mpc
- 30-30 BBH: 0.1477 Gpc
- PRFPMI 10W
- 1.4-1.4 BNS: 19.0 Mpc
- 30-30 BBH: 0.2637 Gpc
- RSE 10W, R_SRM=70%
- 1.4-1.4 BNS: 30.2 Mpc
- 30-30 BBH: 0.4572 Gpc

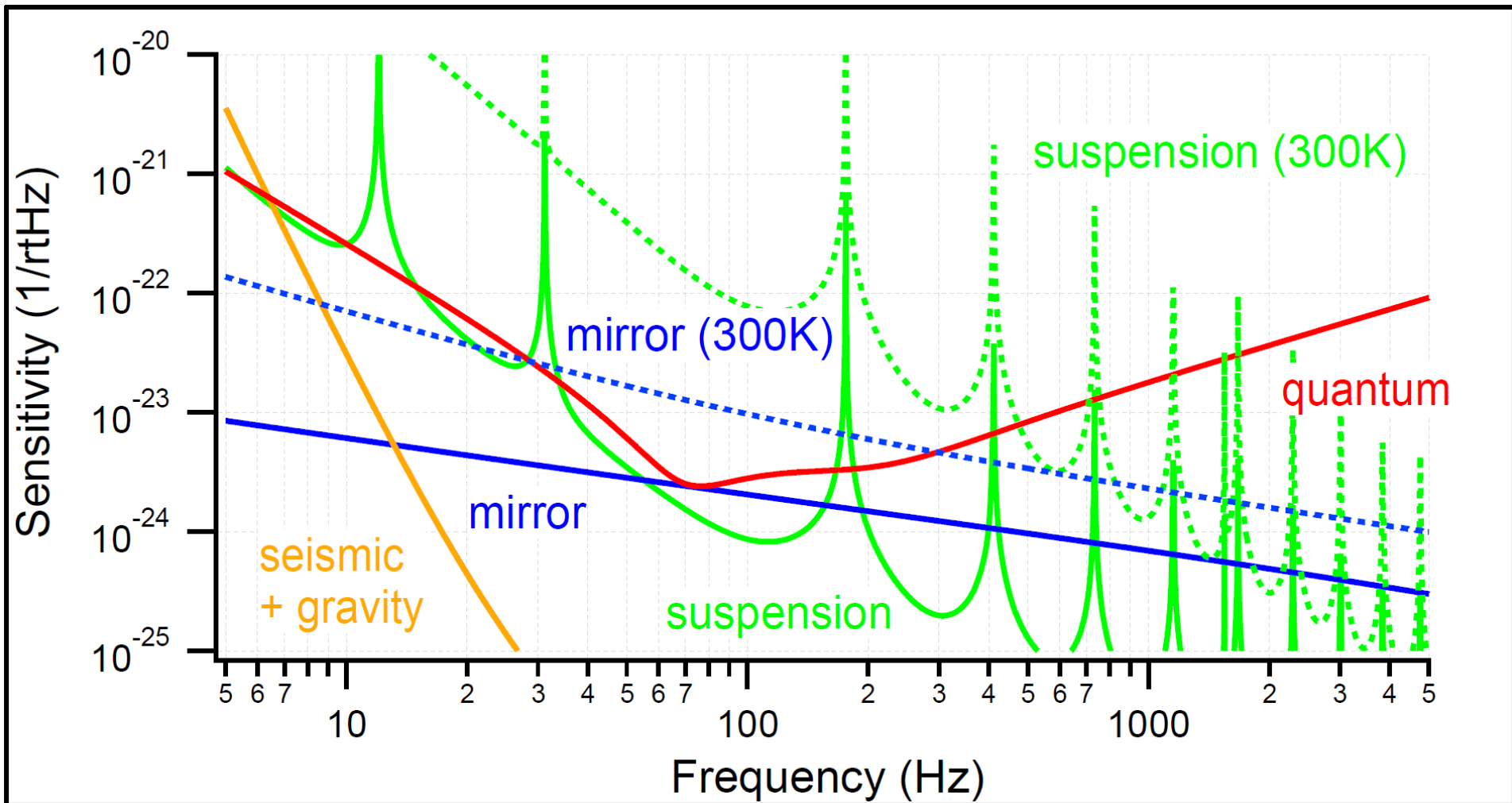
Sensitivity at 300K



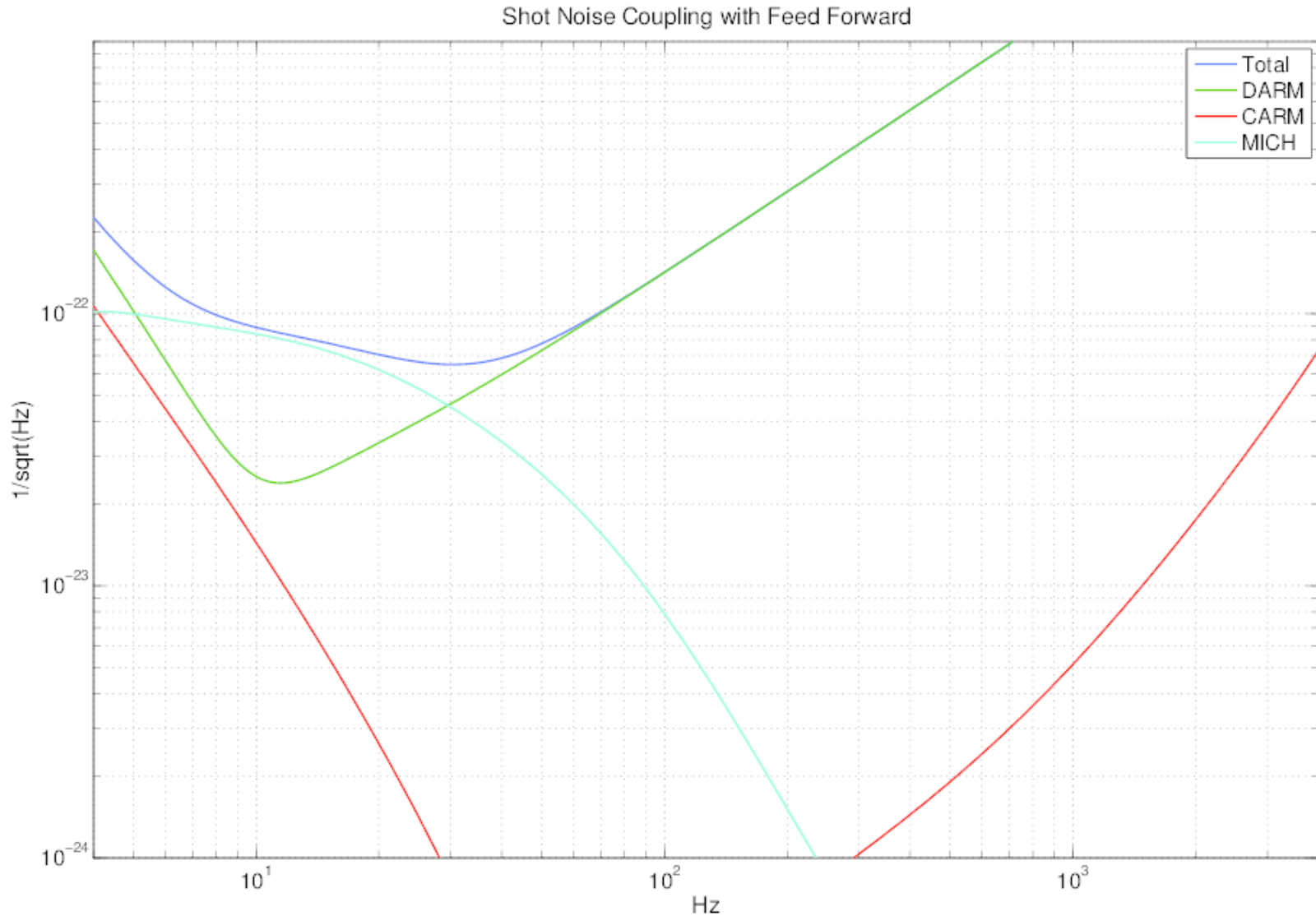
- thermal 22K
- thermal 300K
- FPMI 1W (10W with PRM)
- 1.4-1.4 BNS: 3.1 Mpc
- FPMI 10W
- 1.4-1.4 BNS: 4.9 Mpc
- PRFPMI 10W
- 1.4-1.4 BNS: 6.9 Mpc
- RSE 10W, $R_{\text{SRM}}=70\%$
- 1.4-1.4 BNS: 11.6 Mpc

Cryogenics: Necessary

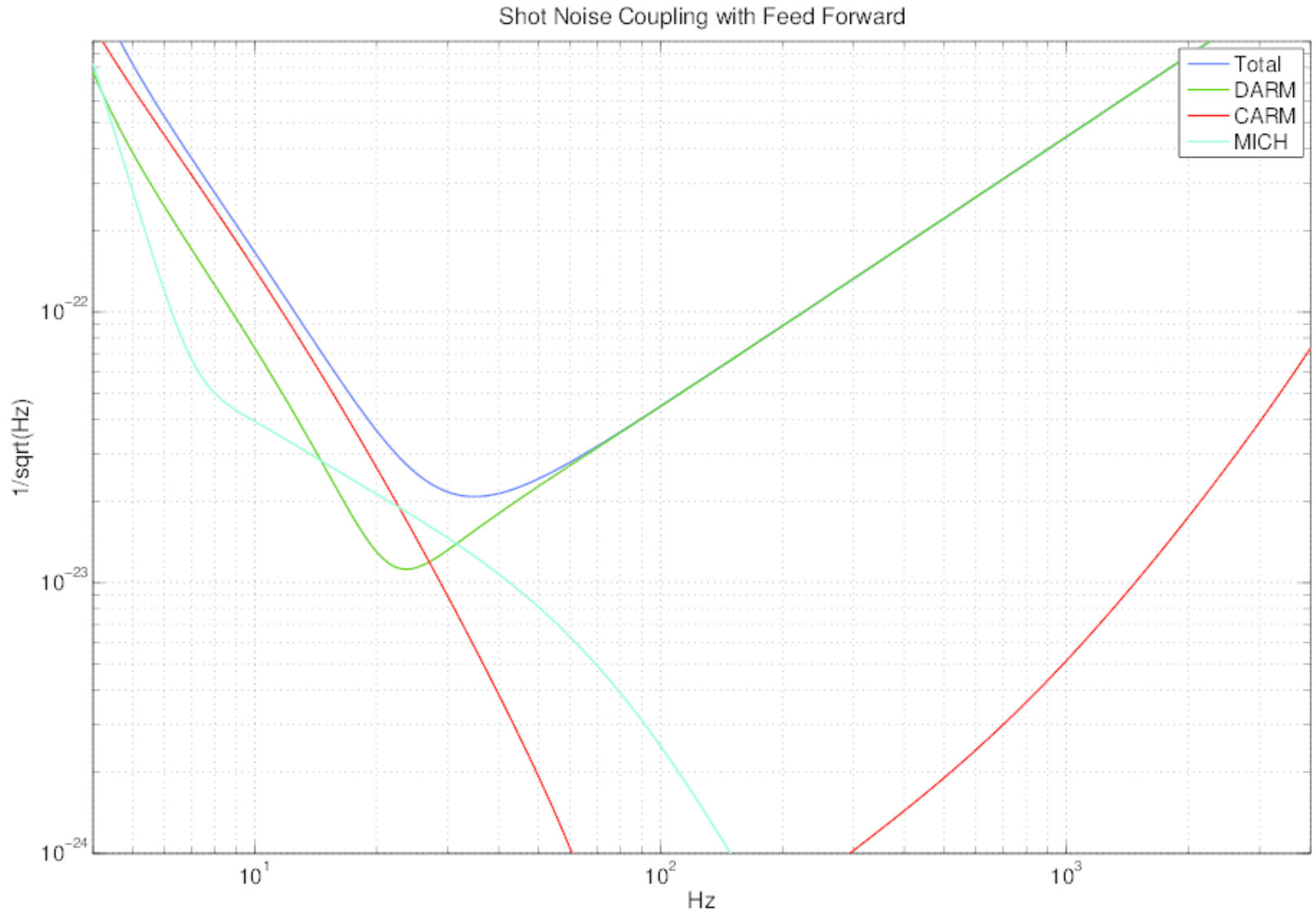
- 300K suspension thermal noise is x100 worse



Shot Noise Coupling **FPMI 1W**

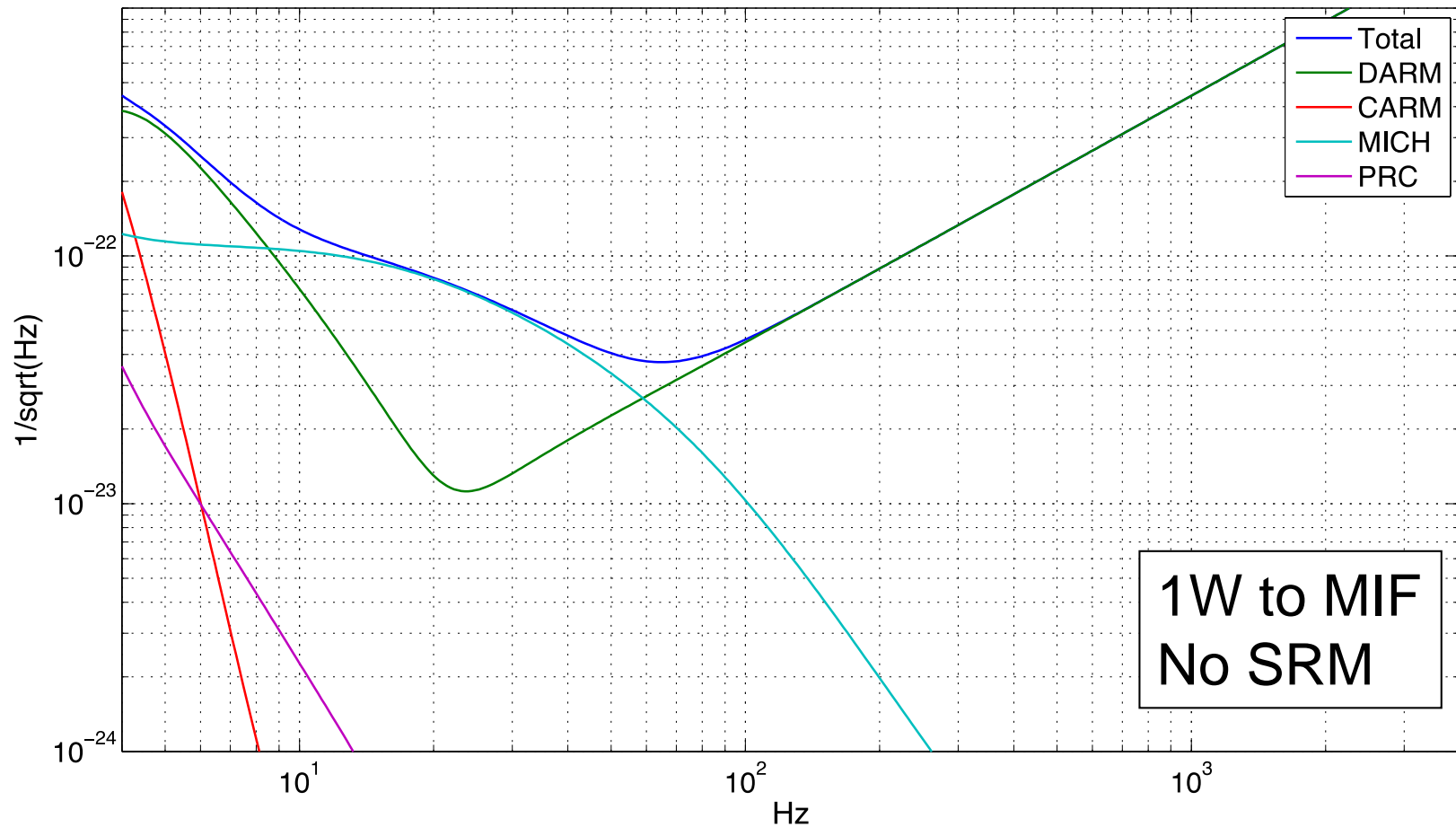


Shot Noise Coupling **FPMI 10W**



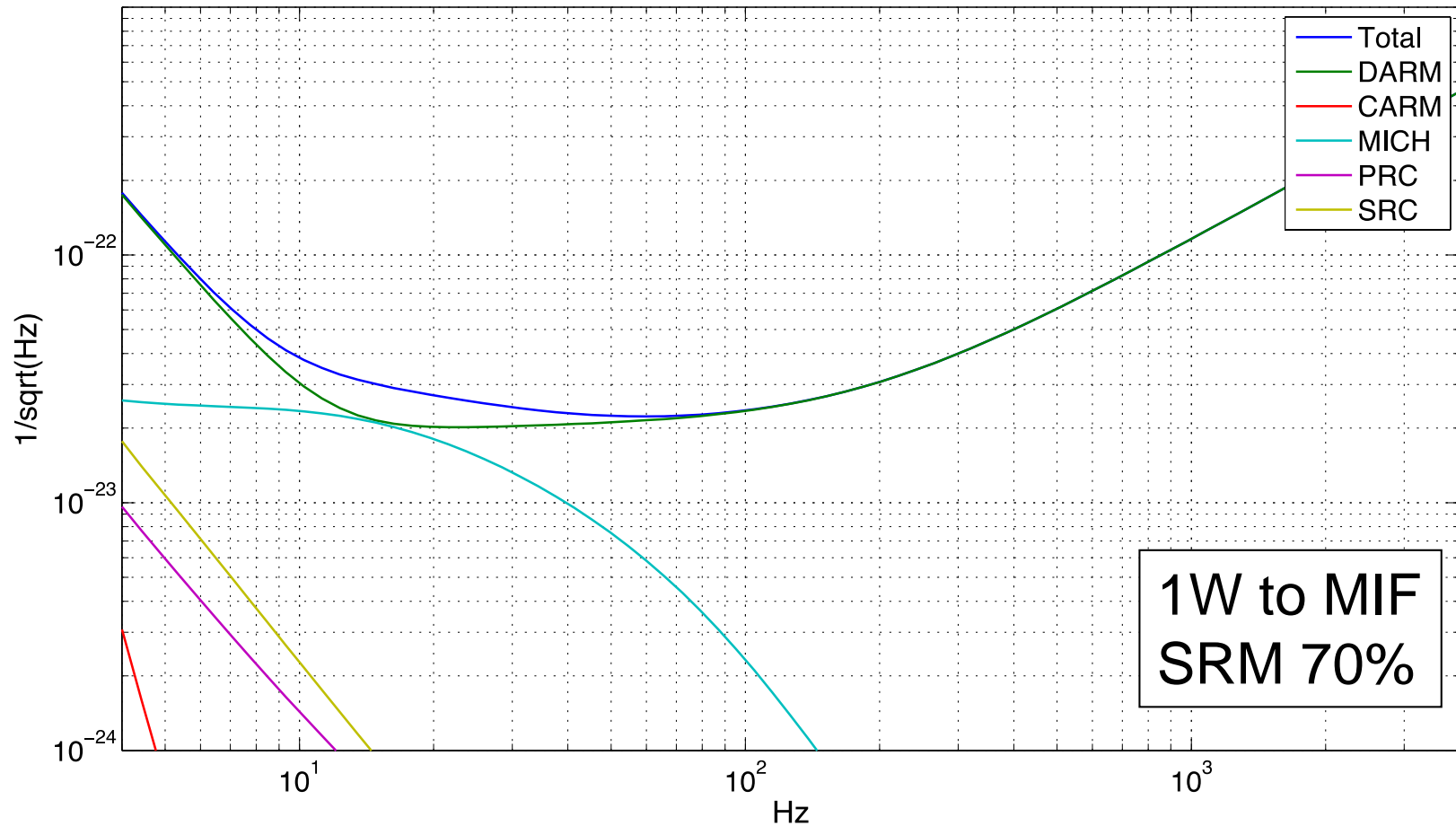
Shot Noise Coupling PRFPMI

Shot Noise Coupling with Feed Forward

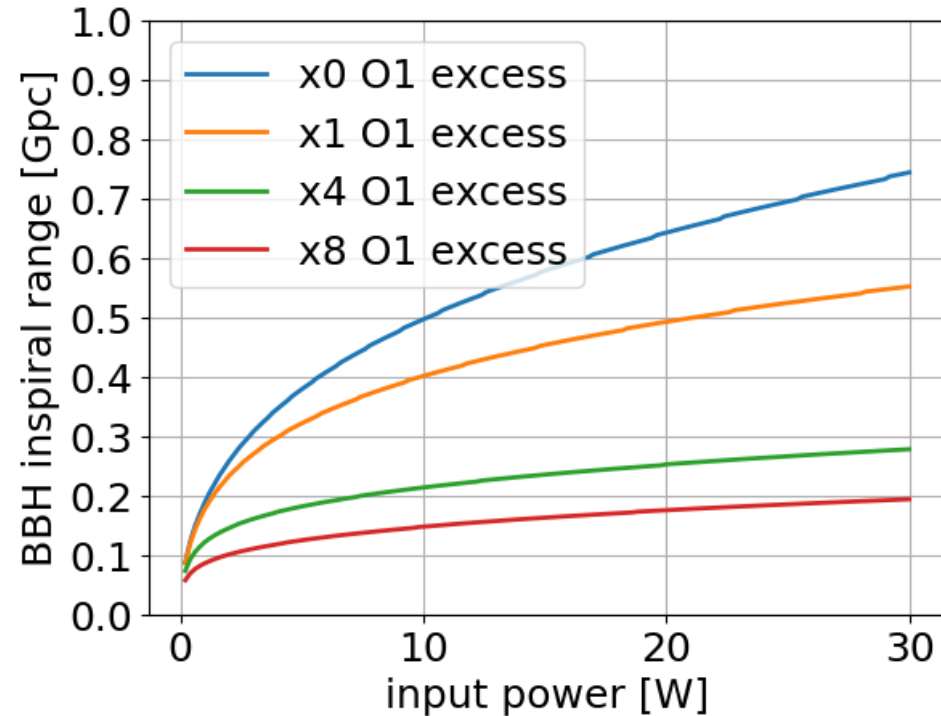
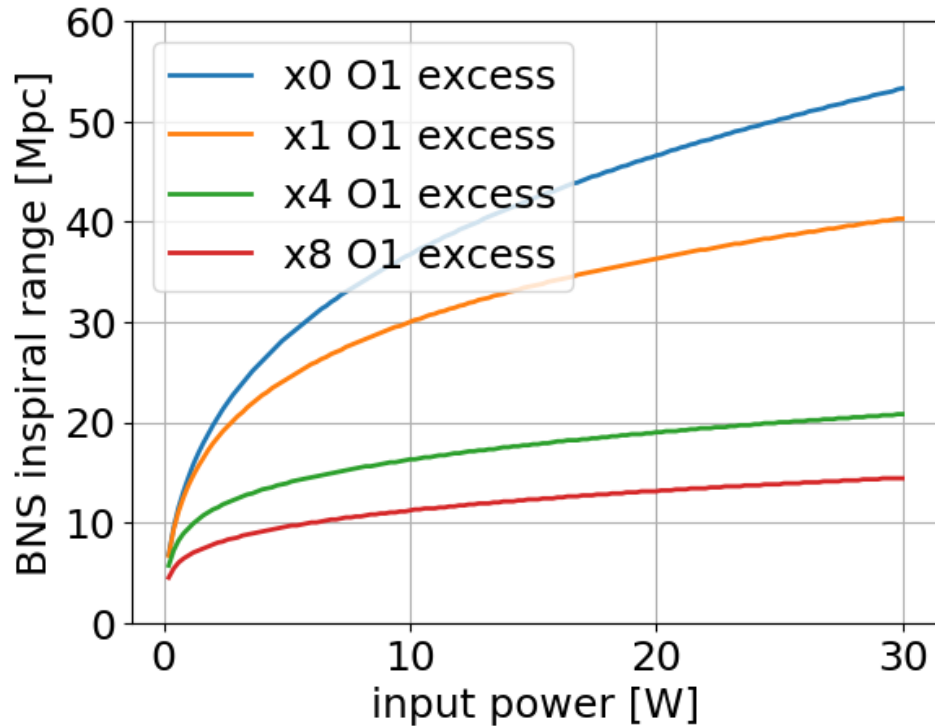


Shot Noise Coupling RSE

Shot Noise Coupling with Feed Forward

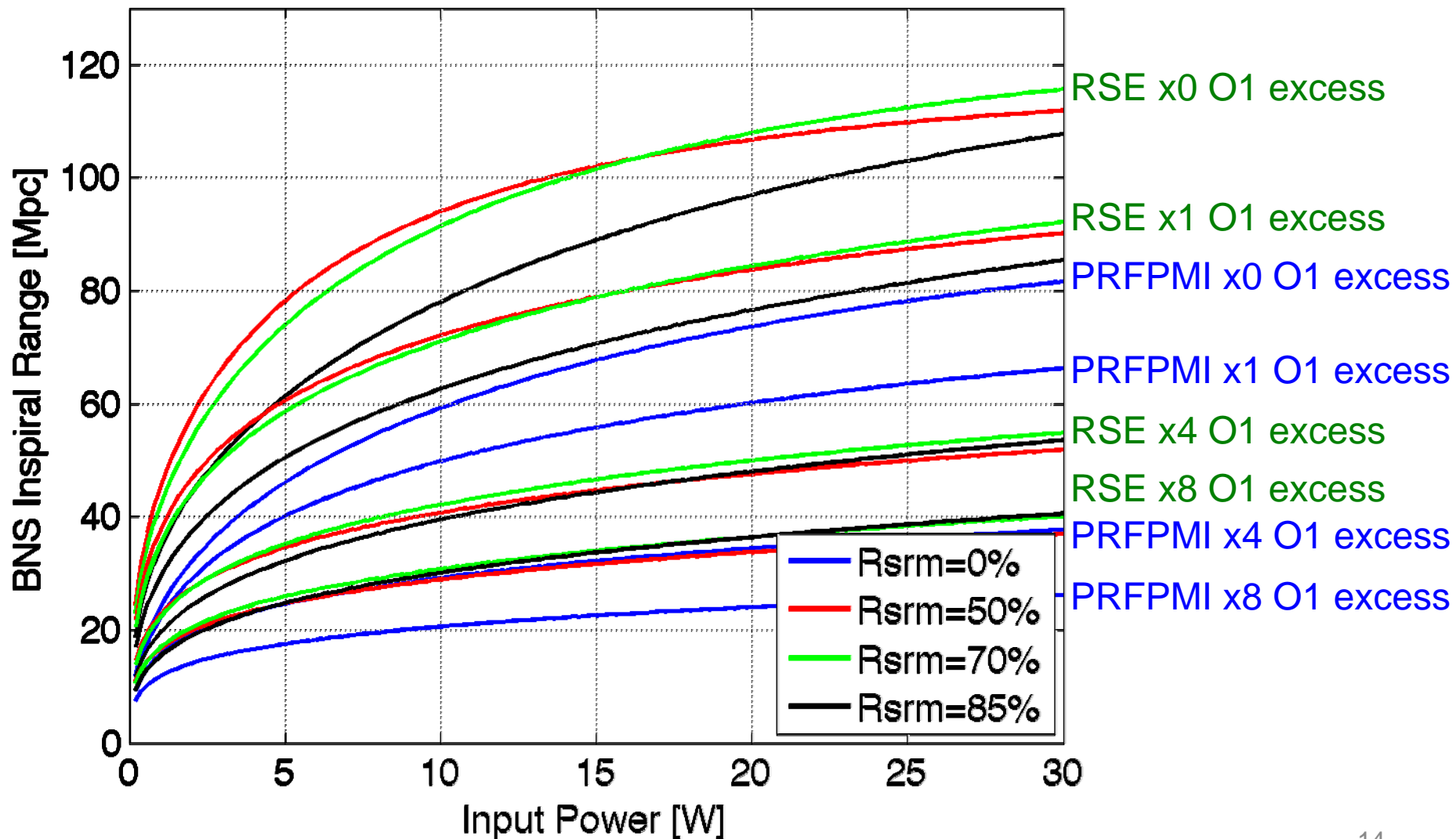


IR vs Power **FPMI**



Note: Shot noise coupling calculation is done only at 10 W and scaled with $1/\sqrt{P}$

IR vs Power PRPFMI/RSE



Necessity

⊙: Necessary for locking

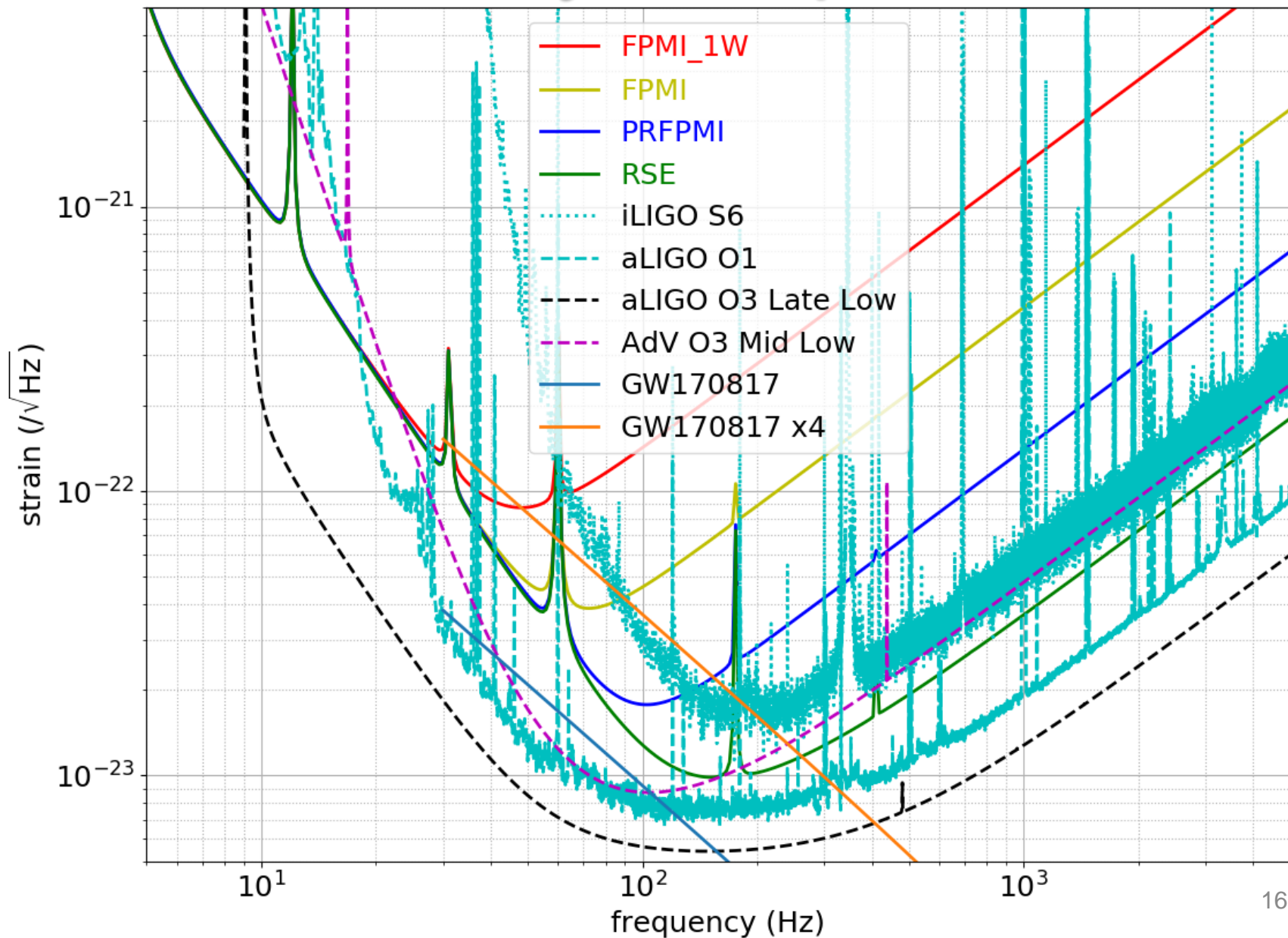
○: Can be omitted with extra work

△: Can be omitted with sensitivity degradation

×: Not necessary

Sensitivity (10W, x4 O1 excess)	RSE (42 Mpc)	PRFPMI (27 Mpc)	FPMI (9.5 / 16 Mpc)
ALS (green lock)	⊙	○	×
f3 AM (MZI)	⊙	○	×
Extra locking simulation	×	⊙	×
SRC ASC	⊙	×	×
SRM	⊙	○ (Blank or move OMMT)	○ (Blank or move OMMT)
OMC	△	△	△
Comment	SRC ASC might be tough	f1 will be 1/10, no SRC mode cleaning	PRM: tilt or blank or move IMMT No PRC jitter attenuation

Sensitivity Comparison

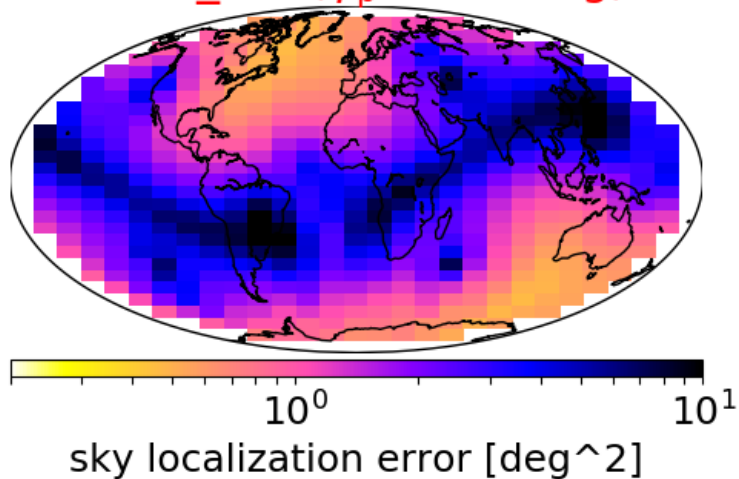


Sky Localization Calculation

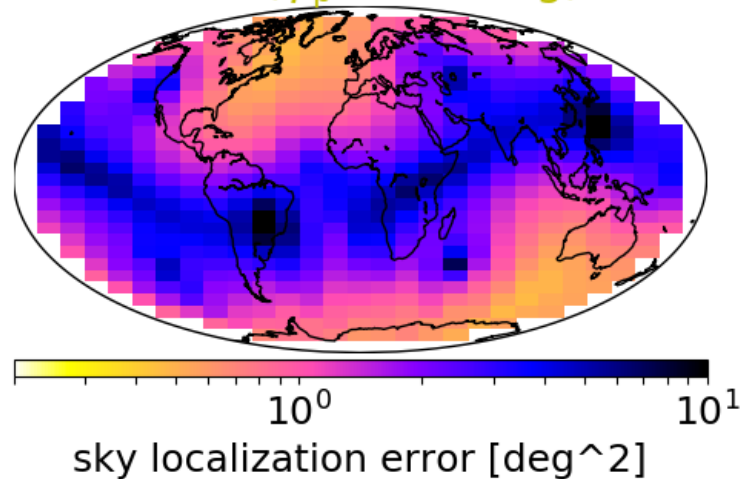
- 10W input, x4 O1 excess noise
- Source parameters (GW170817-like, no spins)
 - redshift: 0.009 (~ 40 Mpc)
 - total/chirp mass: 2.74 / 1.188 Msun
 - inclination angle: 28 deg
 - source locations: equally distributed 648 locations
 - polarization angle: 3 angles
 - > 1944 realizations
- Waveform
 - PhenomD upto inspiral ([PRD 93, 044007 \(2016\)](#))
 - fmin=10Hz, fmax=fISCO~1.6 kHz
- Network sensitivity
 - aLIGO: Late Low (116 Mpc) [LIGO-P1200087](#)
 - AdV: Mid Low (63 Mpc) [LIGO-P1200087](#)
- Fisher analysis (see, also [JGW-T1808090](#))

Sky Localization Map

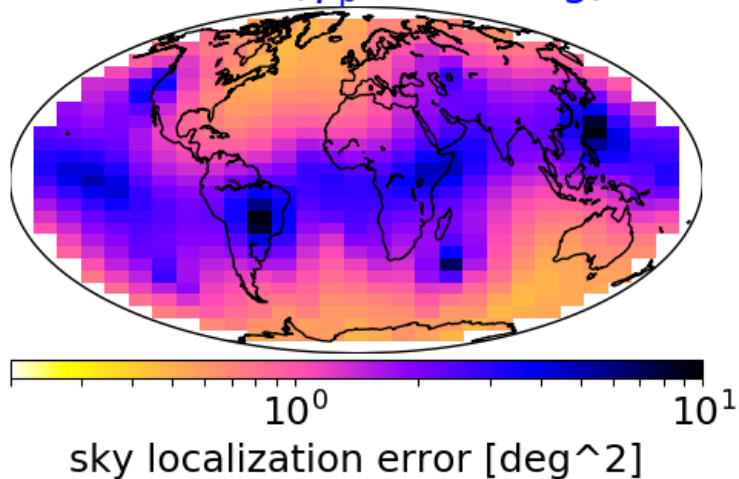
FPMI_1W ($\psi_p = 0.0$ deg)



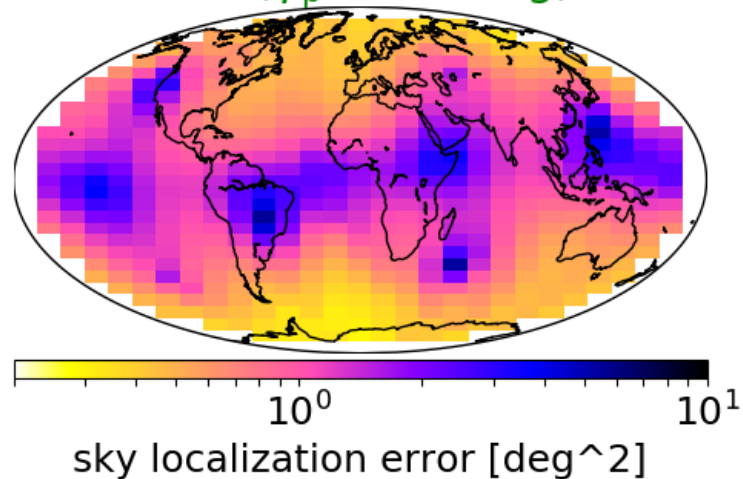
FPMI ($\psi_p = 0.0$ deg)



PRFPMI ($\psi_p = 0.0$ deg)



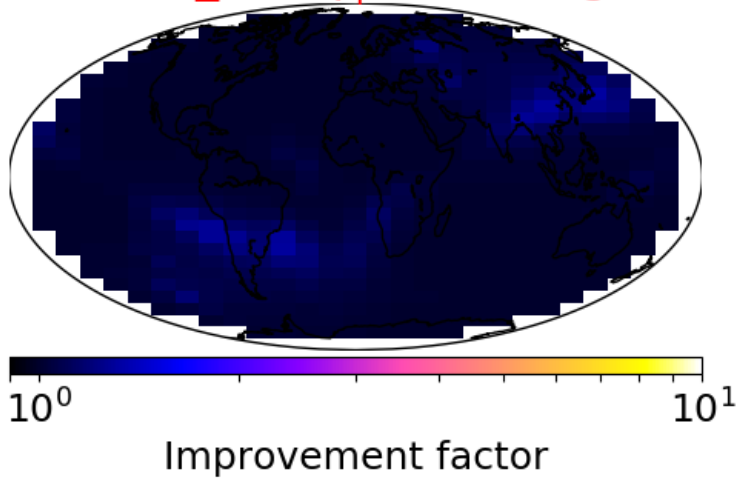
RSE ($\psi_p = 0.0$ deg)



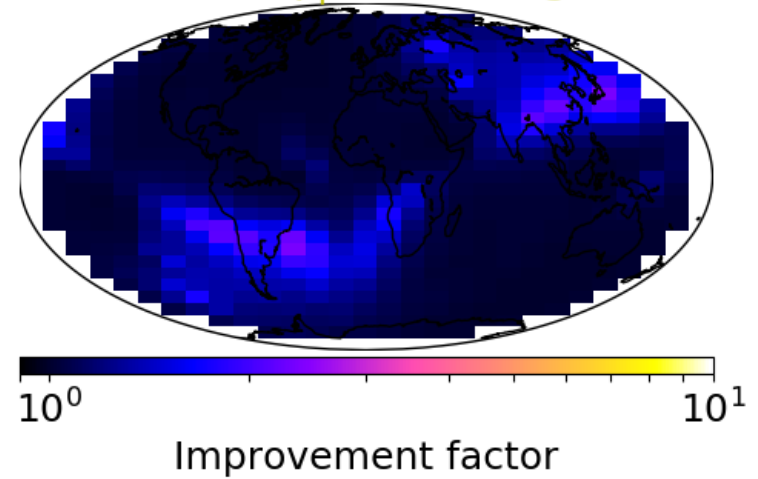
Sky Localization Improvement Map

Improvement factor = $HLVK / HLV$

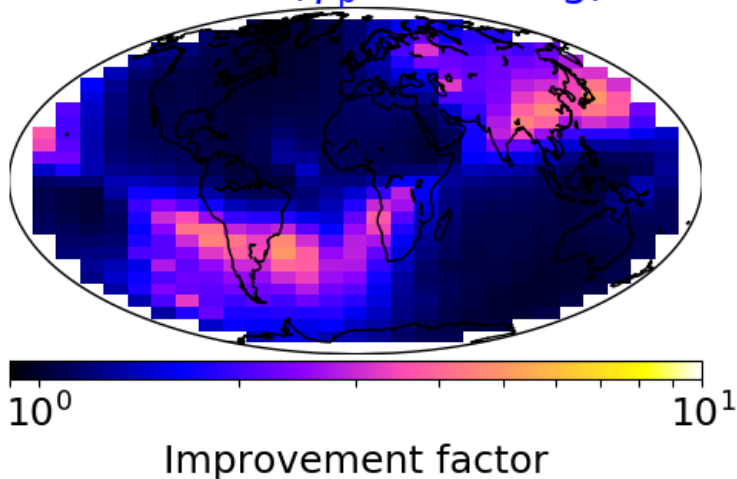
FPMI_1W ($\psi_p = 0.0$ deg)



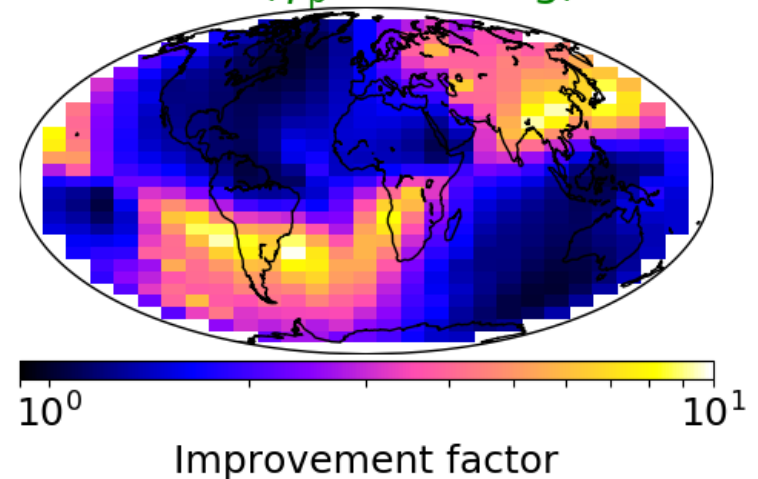
FPMI ($\psi_p = 0.0$ deg)



PRFPMI ($\psi_p = 0.0$ deg)



RSE ($\psi_p = 0.0$ deg)



Sky Localization Distribution

Improvement factor = HLVK / HLV

