laser frequency & intensity noise requirement in ET

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Beam path in the interferometer

Laser noise in signal path:

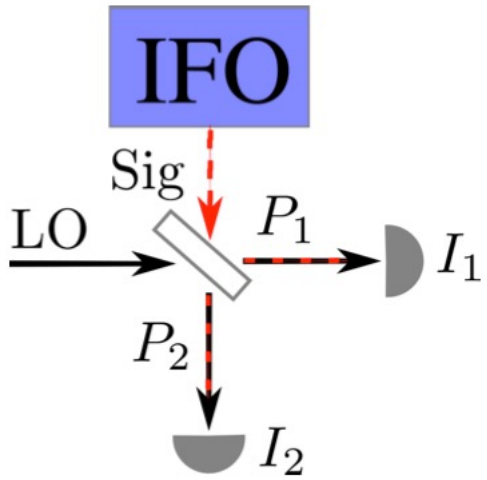
1. Bright port ➞ PRC field , after circulating in coupled PRC-Arm.
2. PRC field ➞ SRC field, due to contrast defect, Schnupp asymmetry.
3. SRC field ➞ dark port, after circulating in coupled SRC-Arm.
4. dark port ➞ readout.

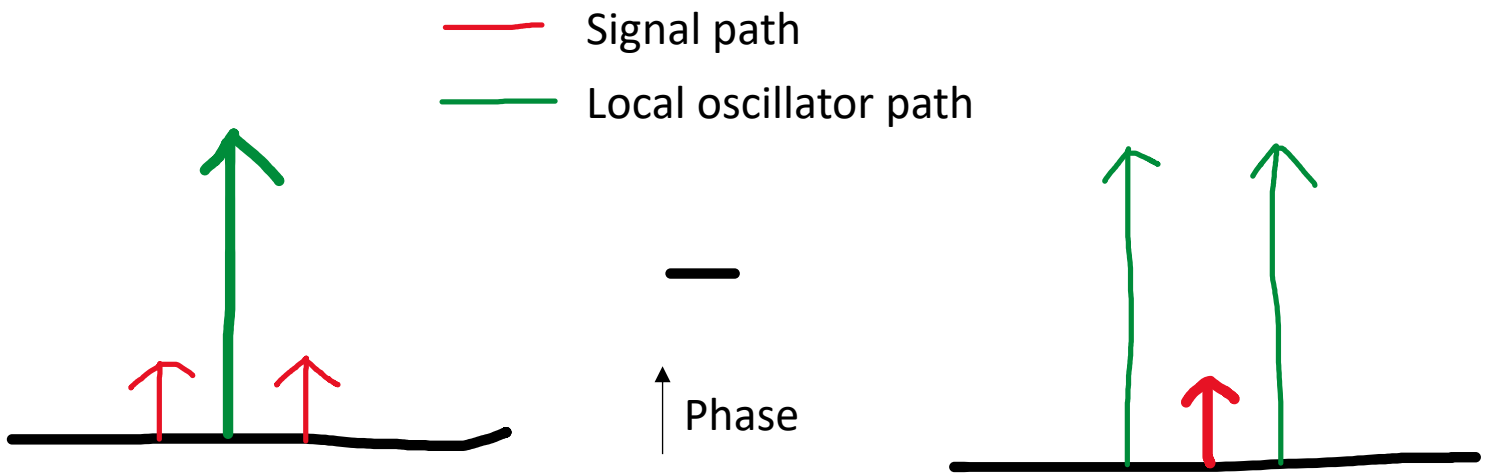
Laser noise in Local oscillator path:

Balanced homodyne readout:

1. Bright port ➞ PRC field , after circulating in coupled PRC-Arm.
2. PRC field ➞ readout.

BHD readout scheme





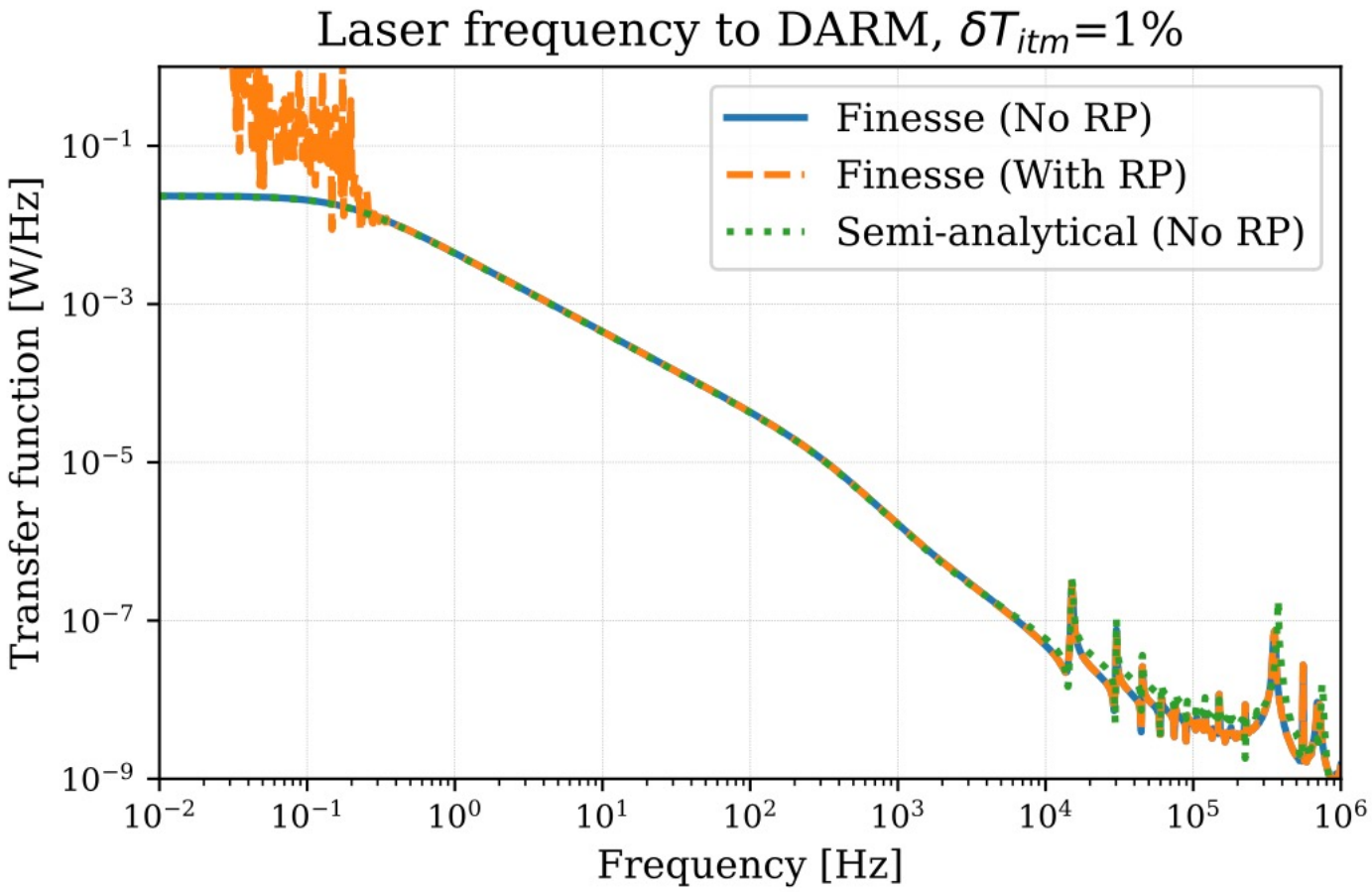
1. Static local oscillator beat against contrast defect noise – Static contrast defect beat against local oscillator noise. (on same phase quadrature)
2. At DC, the frequency noise is canceled.

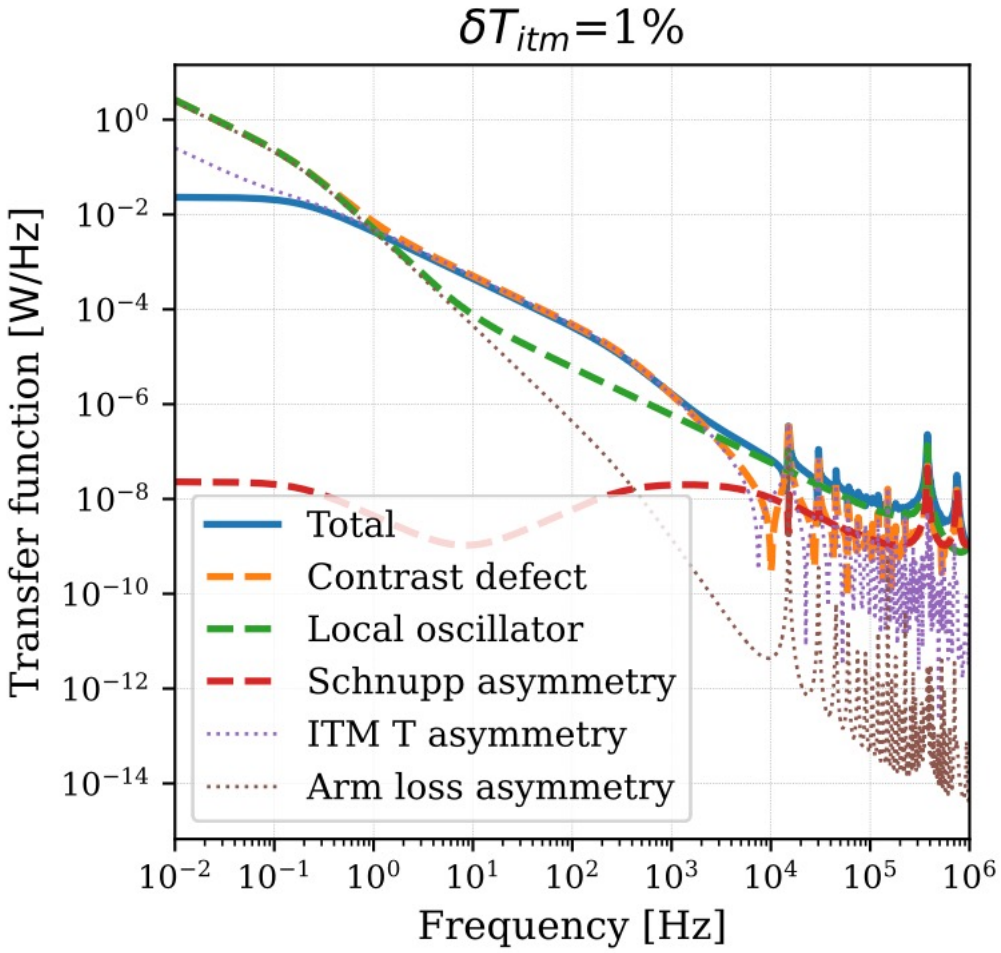
Parameters

Finesse	
ITM T	0.007
ITM T asymmetry	1%
Mirror loss	37.5e-6
Loss asymmetry	10%
LO power	100mW
Dark port power	1.41mW

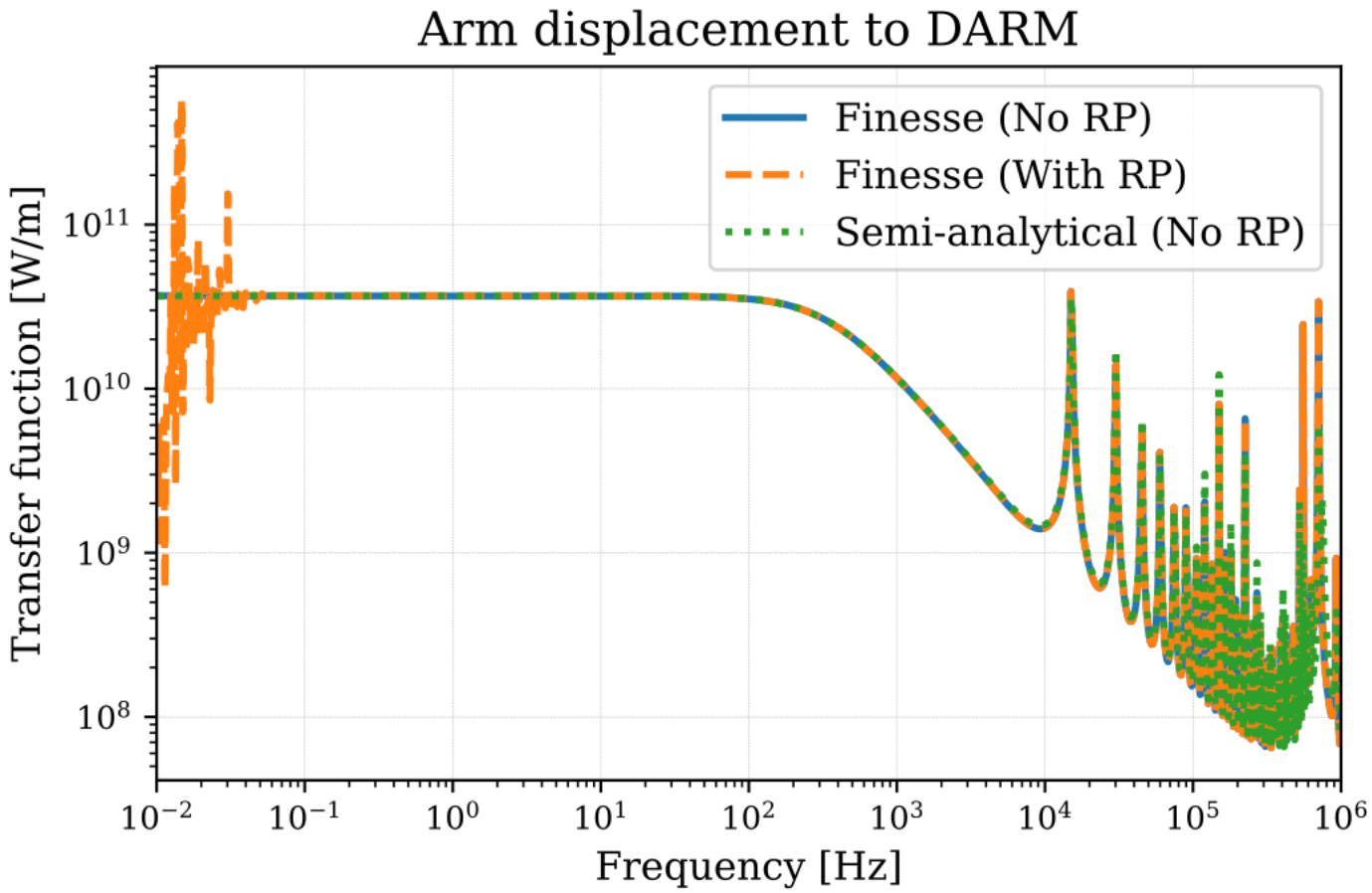
Semi-analytical	
ITM T	0.007
ITM T asymmetry	1%
Mirror loss	37.5e-6
Loss asymmetry	10%
LO power	100mW
Dark port power	1.56mW

Frequency noise TF in W/Hz





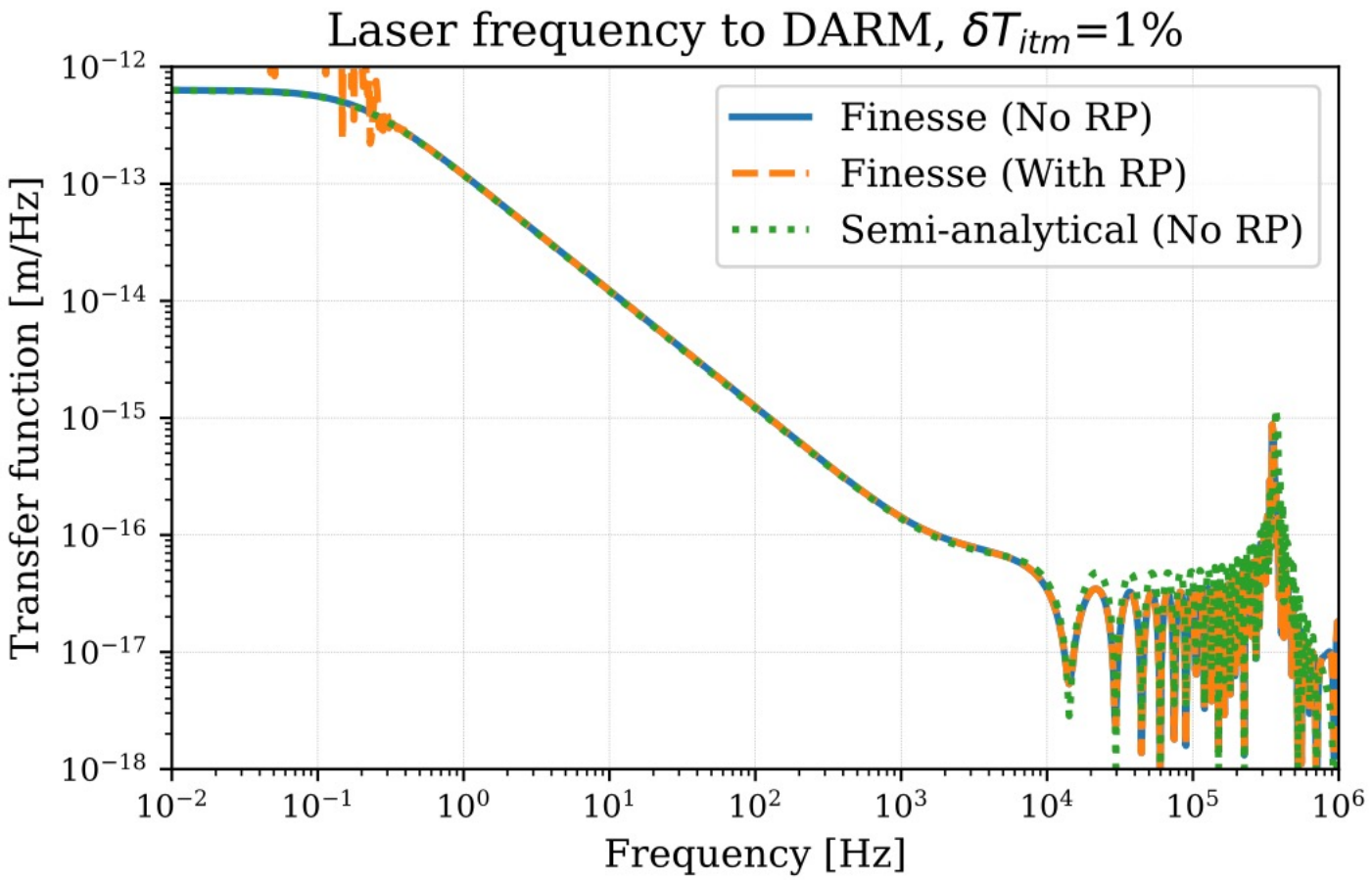
Darm motion TF in W/m

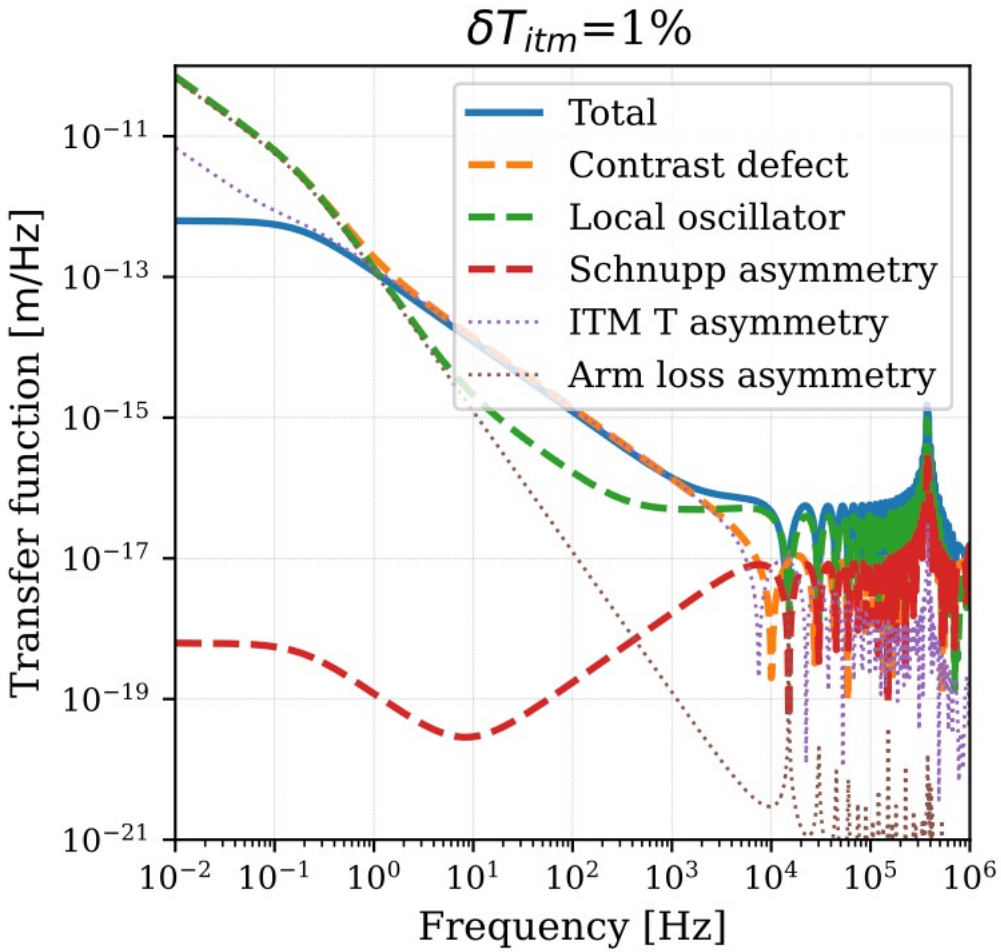


Frequency noise

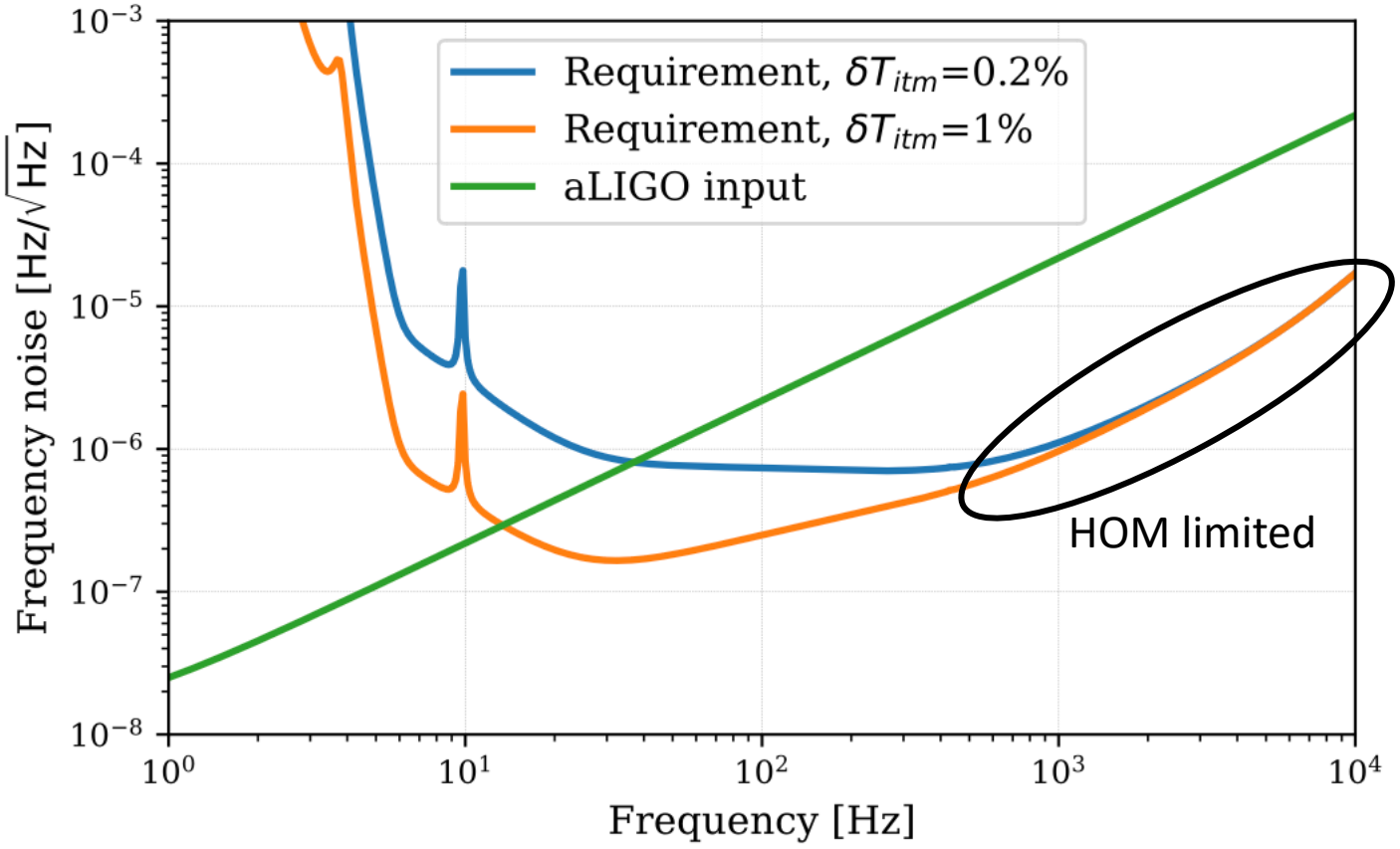
HF

Calibrate frequency noise to equivalent darm motion in $\frac{\mathrm{m}}{\mathrm{Hz}} = \frac{\mathrm{W}}{\mathrm{Hz}} / \frac{\mathrm{W}}{\mathrm{m}}$





Requirement (result from finesse including RP)



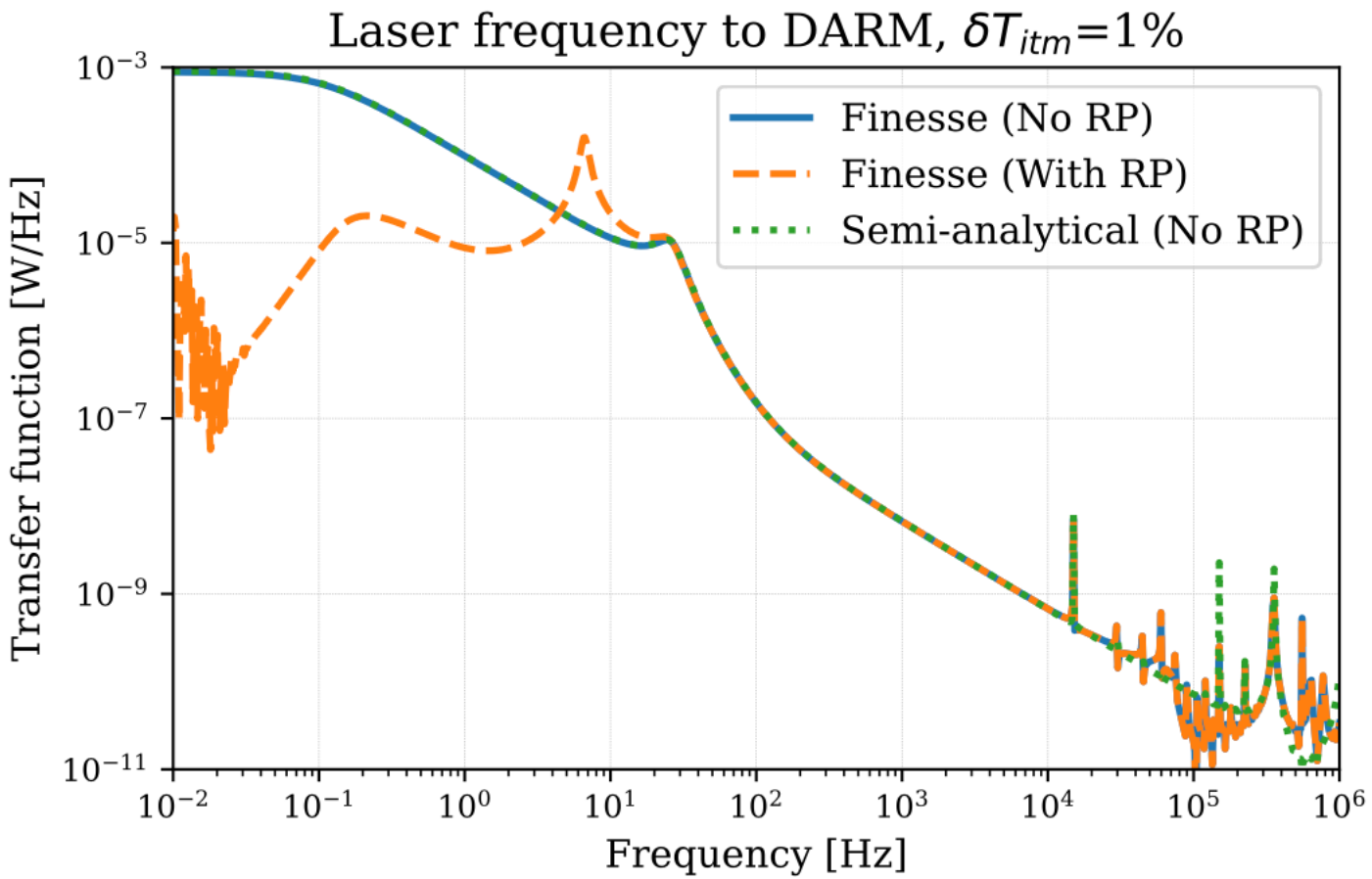
Including a factor of 10 safe margin and 0.4e-15m/Hz constant noise from HOM.

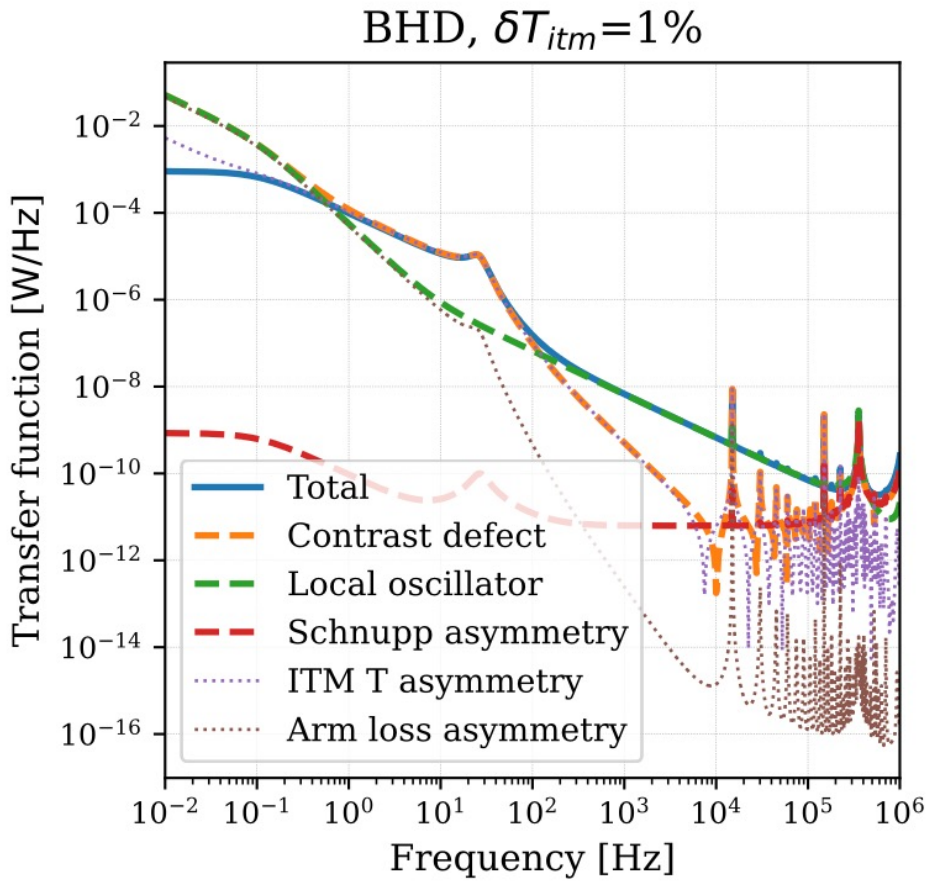
Parameters

Finesse	
ITM T	0.007
ITM T asymmetry	1%
Mirror loss	20e-6
Loss asymmetry	10%
LO power	10mW
Dark port power	6.34uW

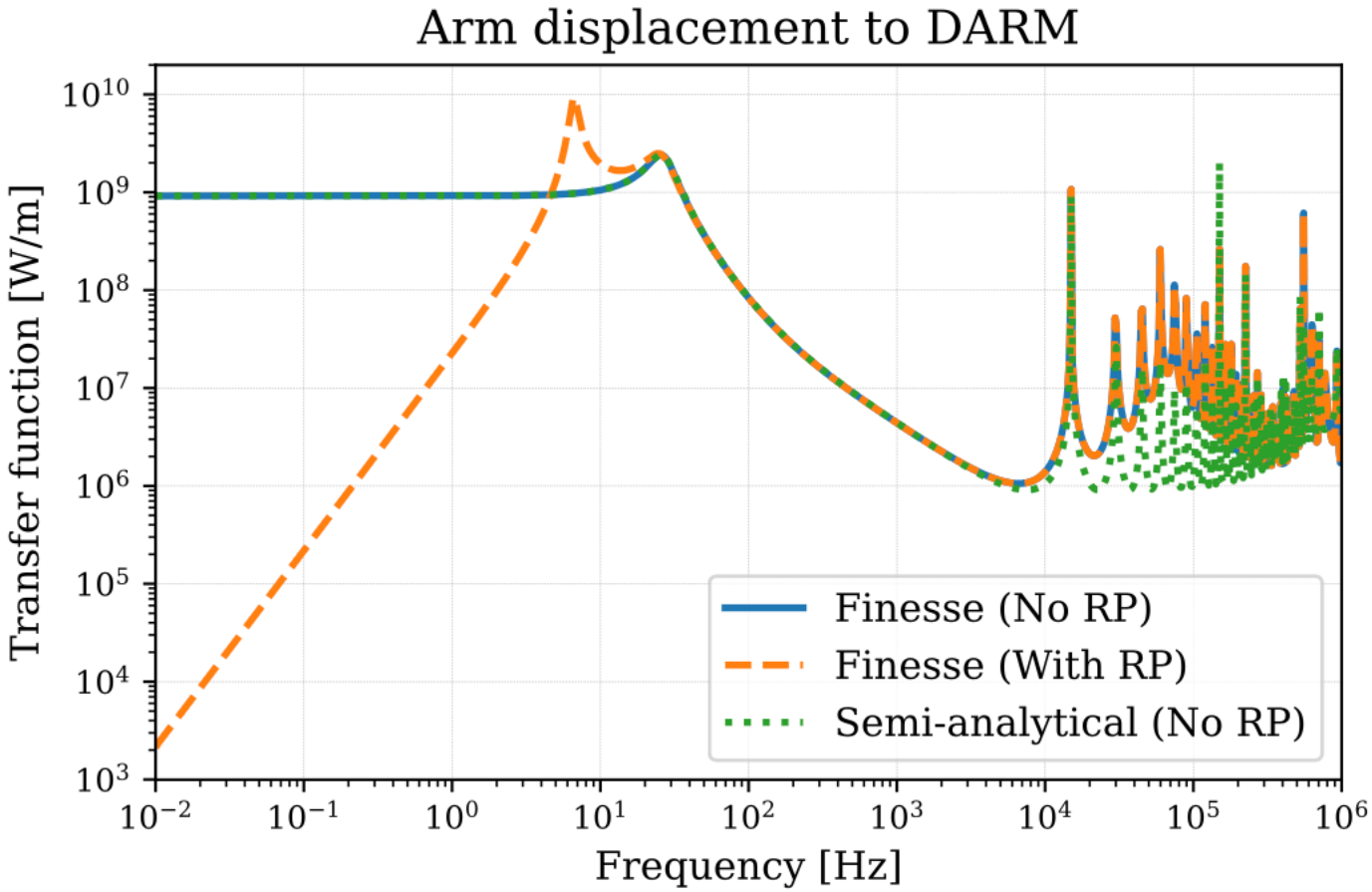
Semi-analytical	
ITM T	0.007
ITM T asymmetry	1%
Mirror loss	20e-6
Loss asymmetry	10%
LO power	10mW
Dark port power	6.37uW

Frequency noise TF in W/Hz





Darm motion TF in W/m

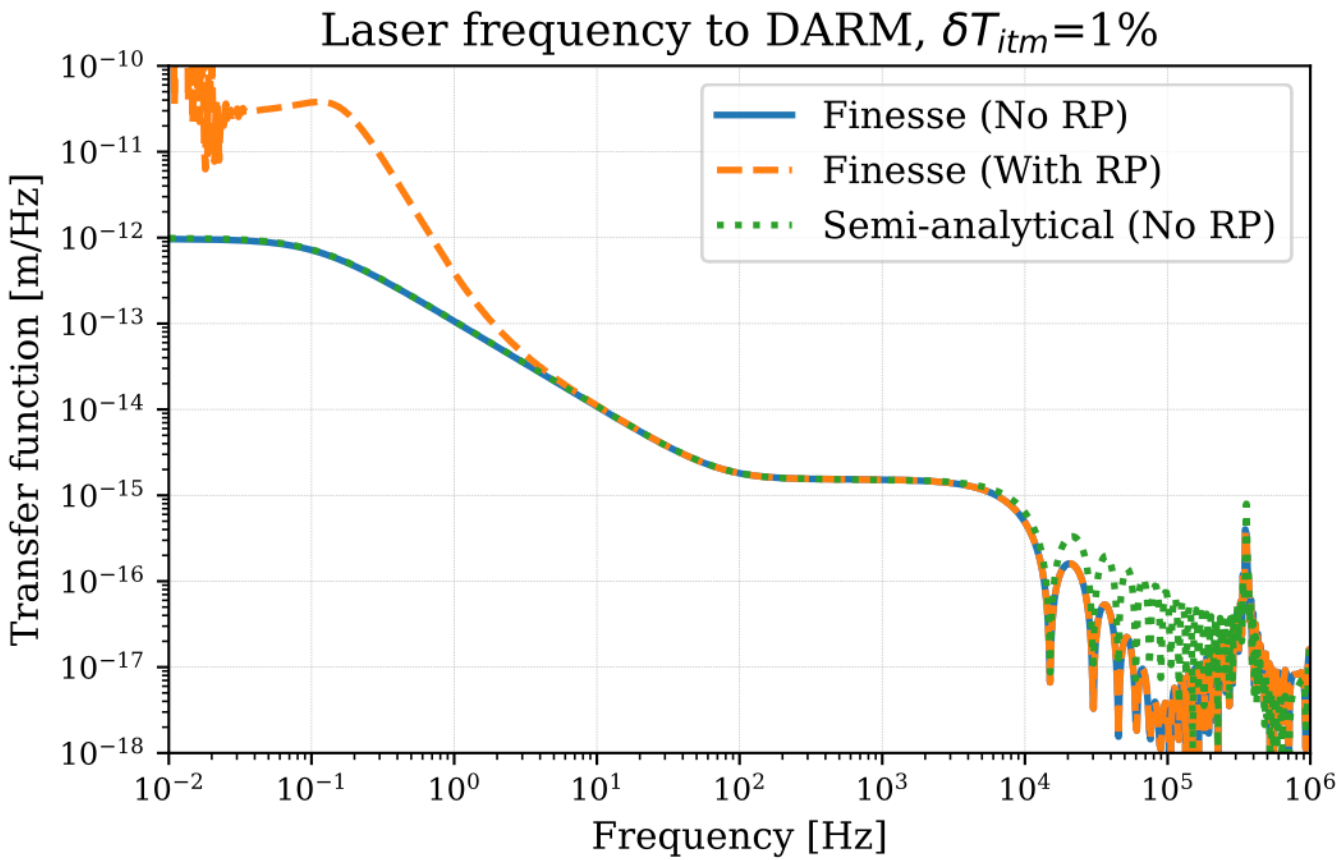


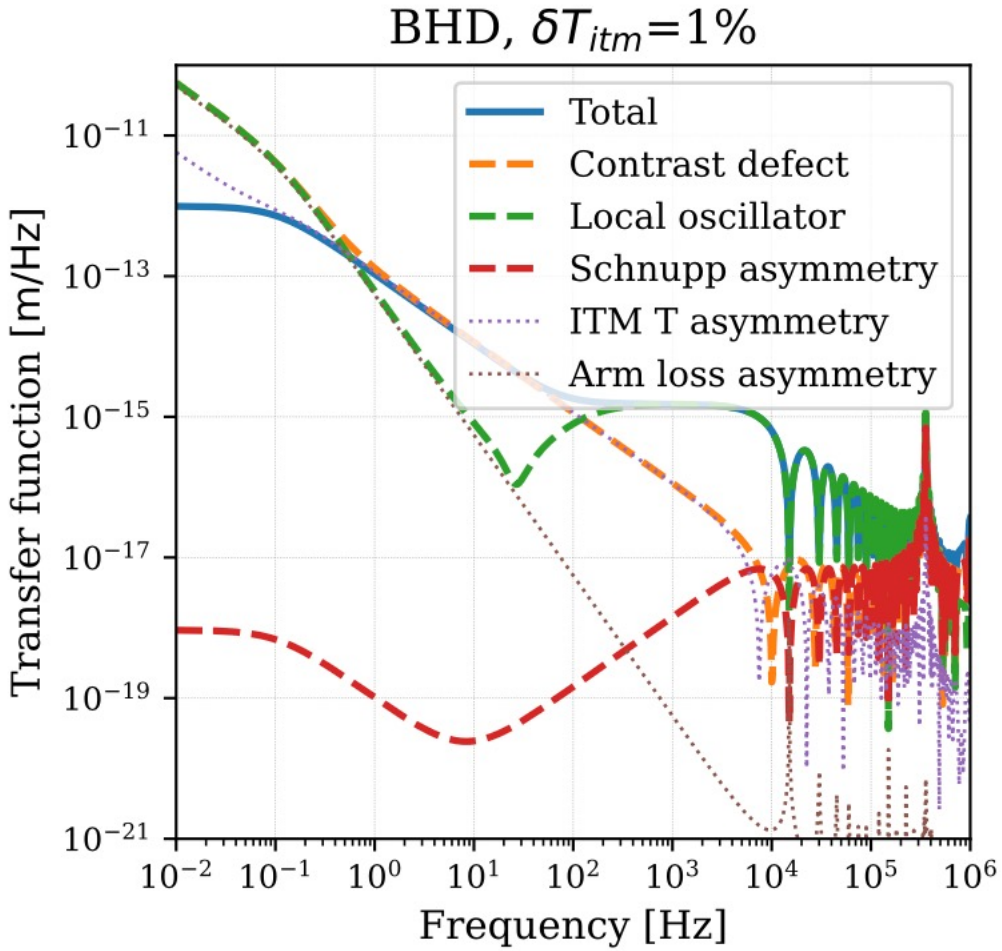
In Finesse, note that to measure the phase quadrature with SRM 34.2° detuned, the LO phase is set to −17.2°.

Frequency noise

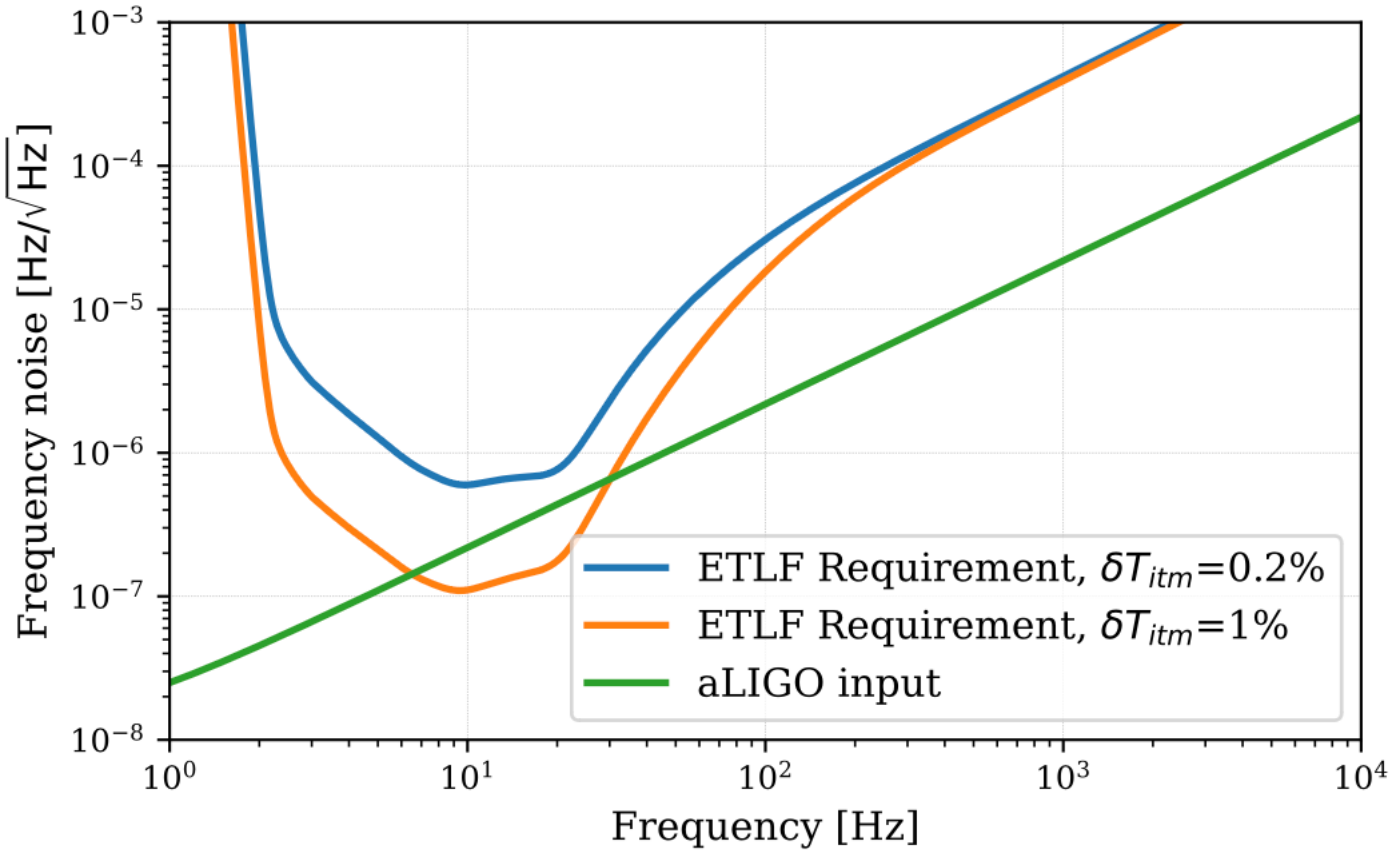
LF

Calibrate frequency noise to equivalent darm motion in $\frac{\mathrm{m}}{\mathrm{Hz}} = \frac{\mathrm{W}}{\mathrm{Hz}} / \frac{\mathrm{W}}{\mathrm{m}}$





Requirement (result from finesse including RP)



Including a factor of 10 safe margin and 0.4e-15m/Hz constant noise from HOM.

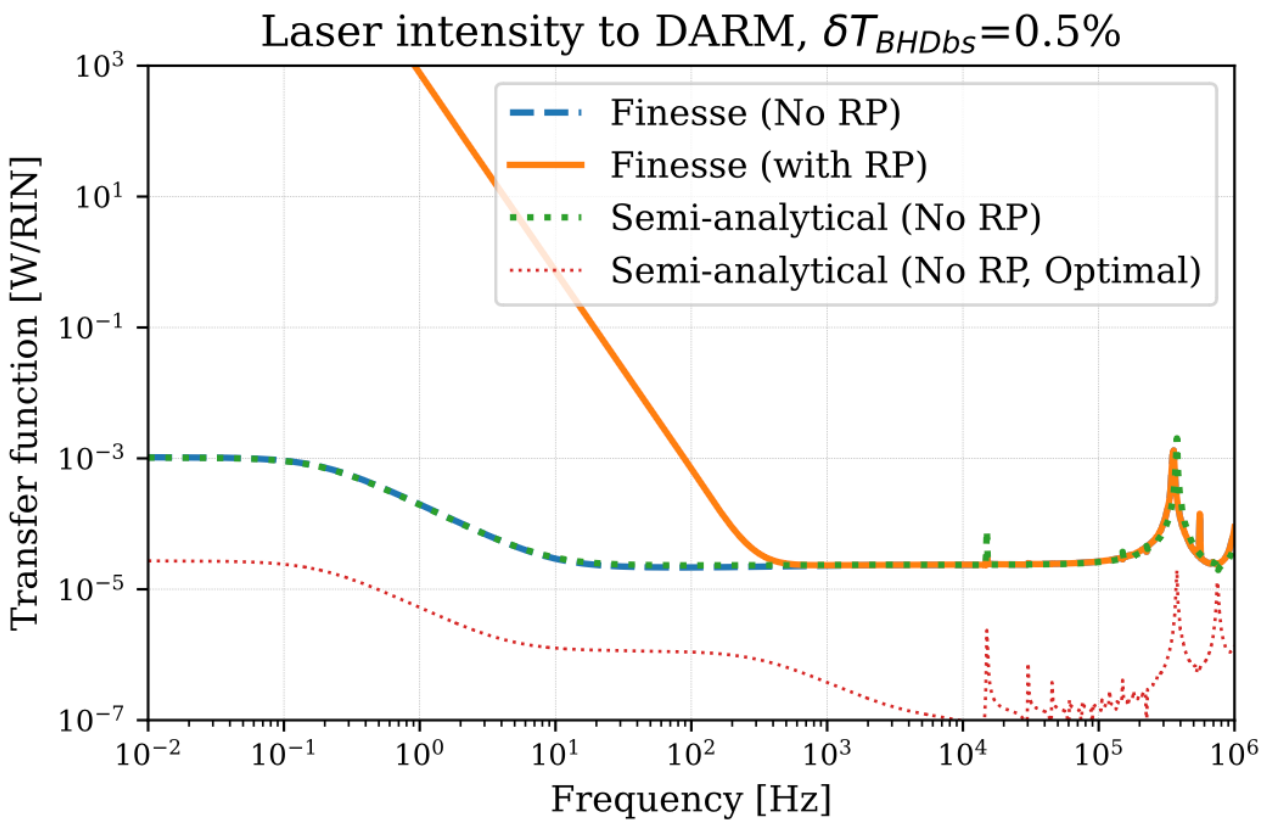
Parameters

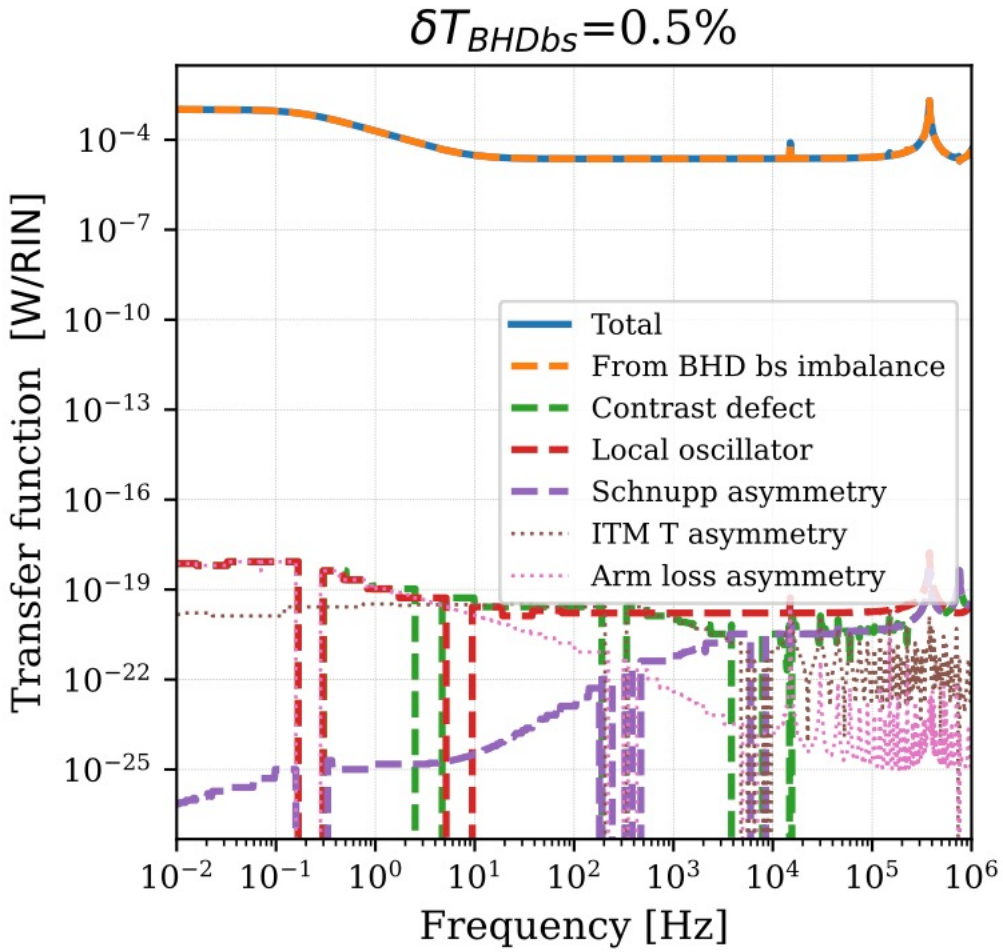
Finesse	
ITM T	0.007
ITM T asymmetry	1%
Mirror loss	20e-6
Loss asymmetry	10%
BHD BS asymmetry	0.5%
LO power	100mW
Dark port power	1.41mW

Semi-analytical	
ITM T	0.007
ITM T asymmetry	1%
Mirror loss	37.5e-6
Loss asymmetry	10%
BHD BS asymmetry	0.5%
LO power	100mW
Dark port power	1.56mW

The LO static field (on phase quadrature) is orthogonal to the amplitude noise in signal beam. Here an imperfection on BHD beamsplitter can introduce the noise from LO itself. : LO static field x the local noise.

Intensity noise TF in W/RIN

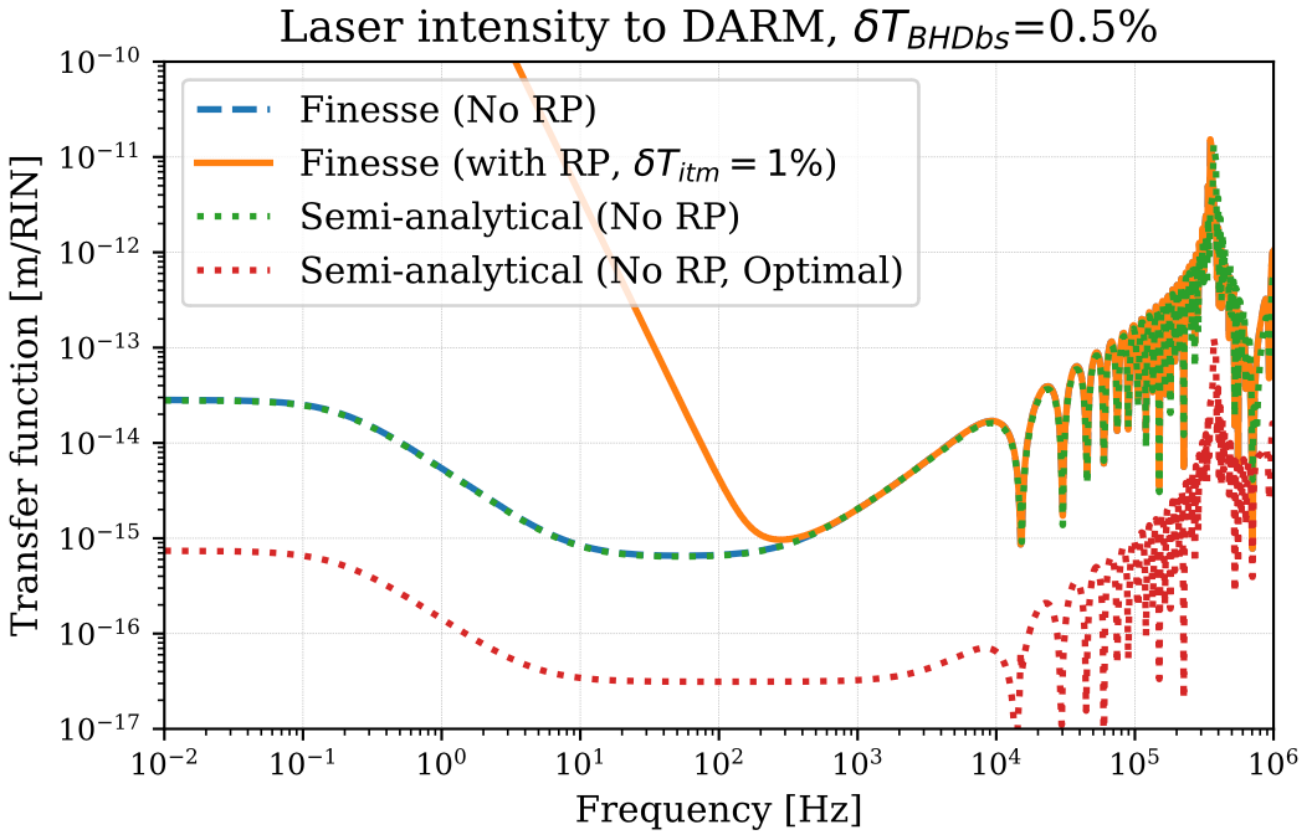


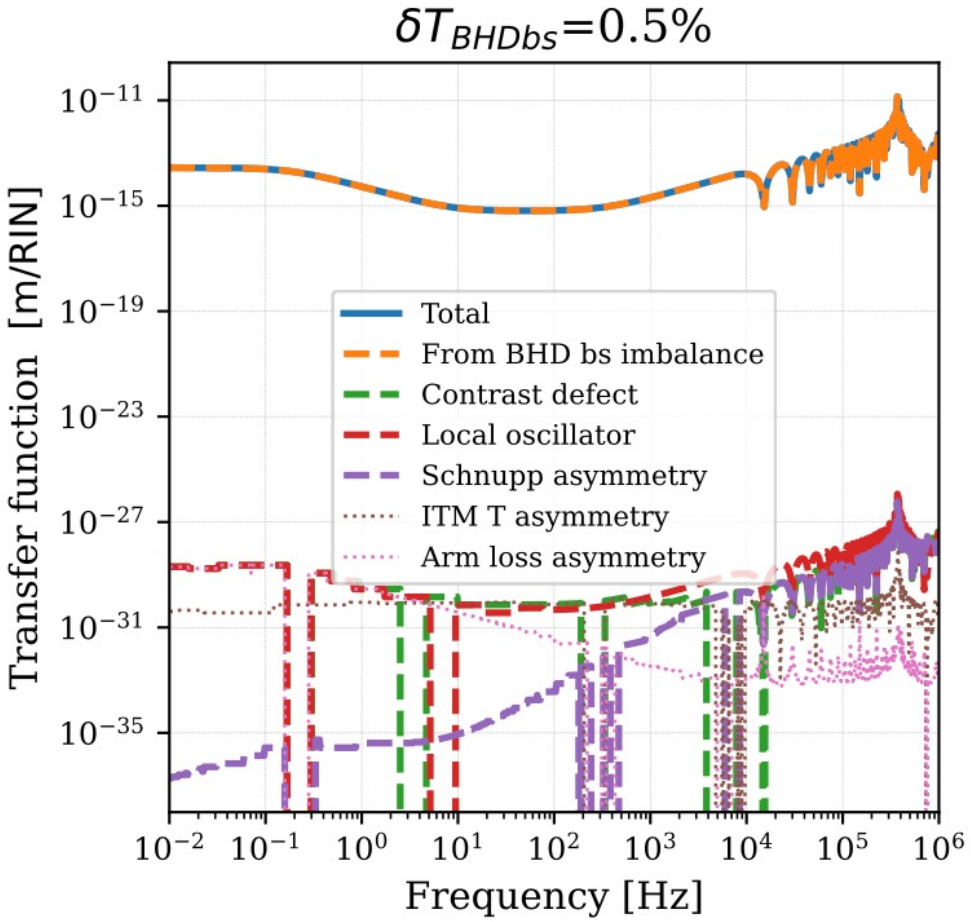


Intensity noise

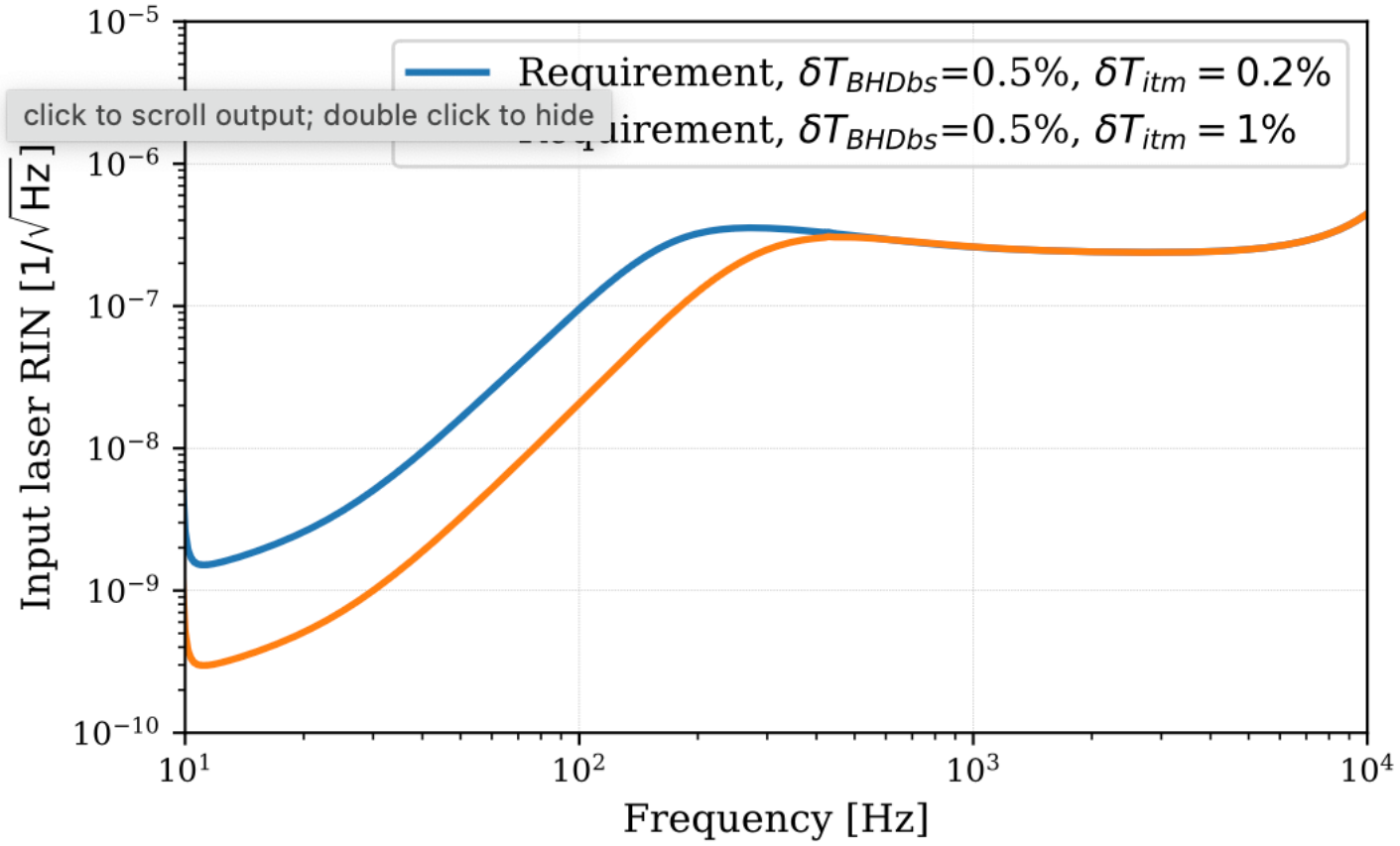
HF

Calibrate intensity noise to equivalent darm motion in $\frac{\mathrm{m}}{\mathrm{RIN}} = \frac{\mathrm{W}}{\mathrm{RIN}} / \frac{\mathrm{W}}{\mathrm{m}}$





Requirement



Including a factor of 10 safe margin.

Parameters

Semi-analytical	
ITM T	0.007
ITM T asymmetry	1%
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LO power	10mW
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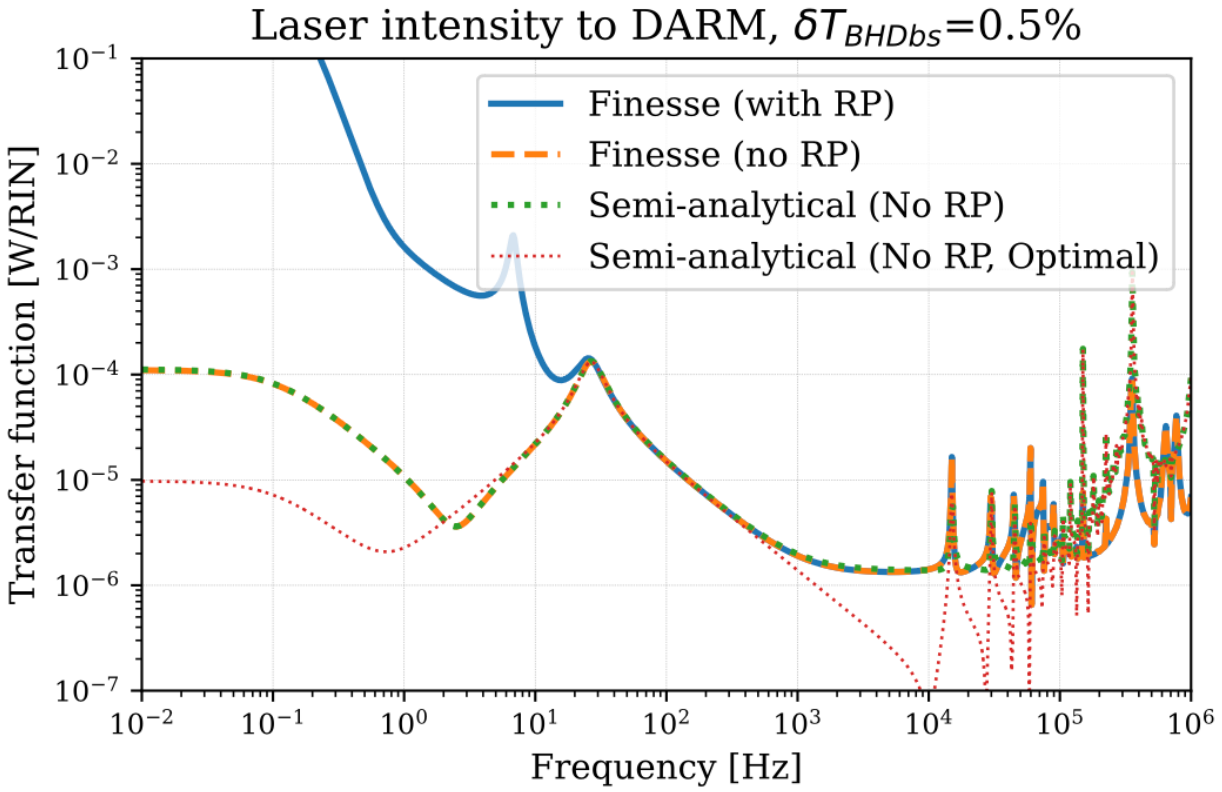
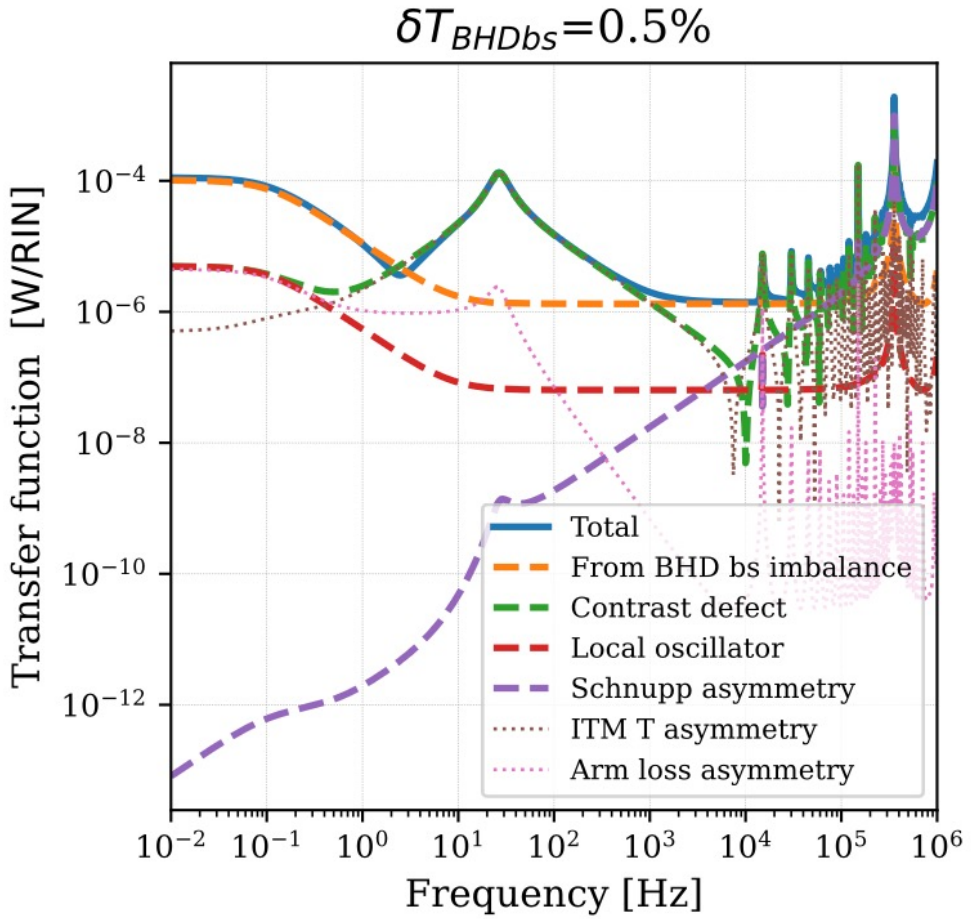
Intensity noise TF in W/Hz

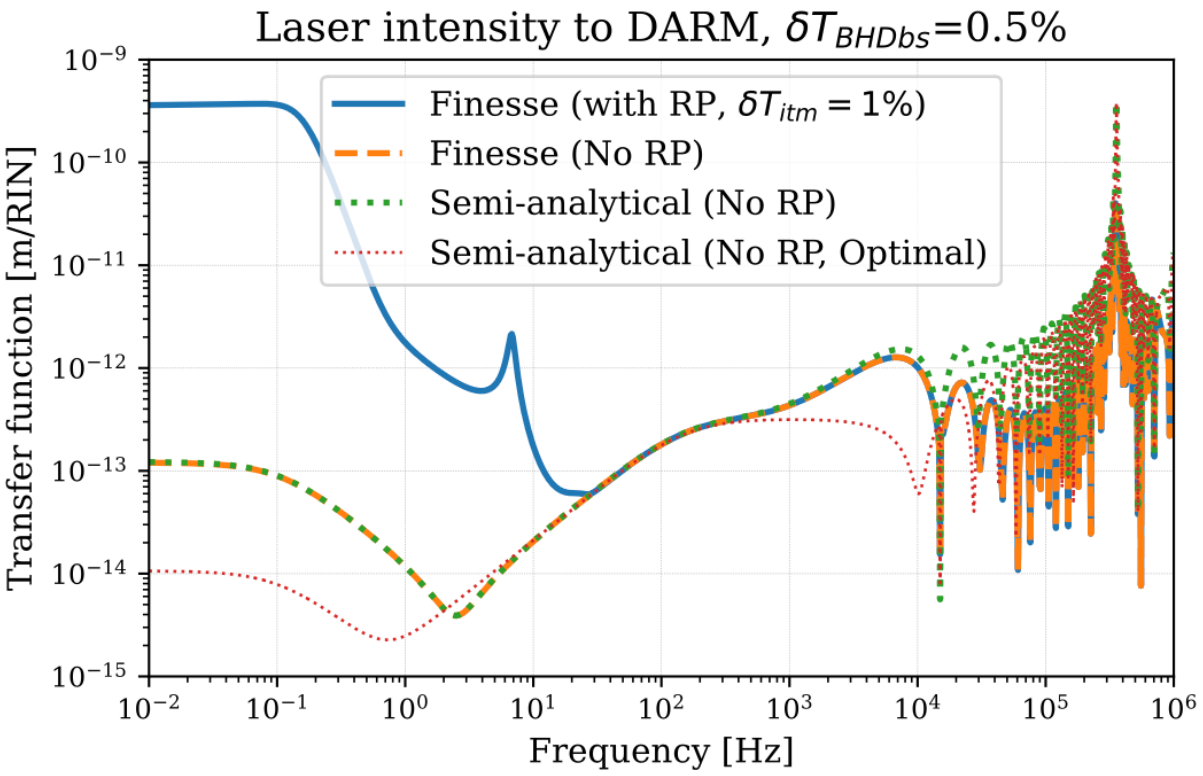


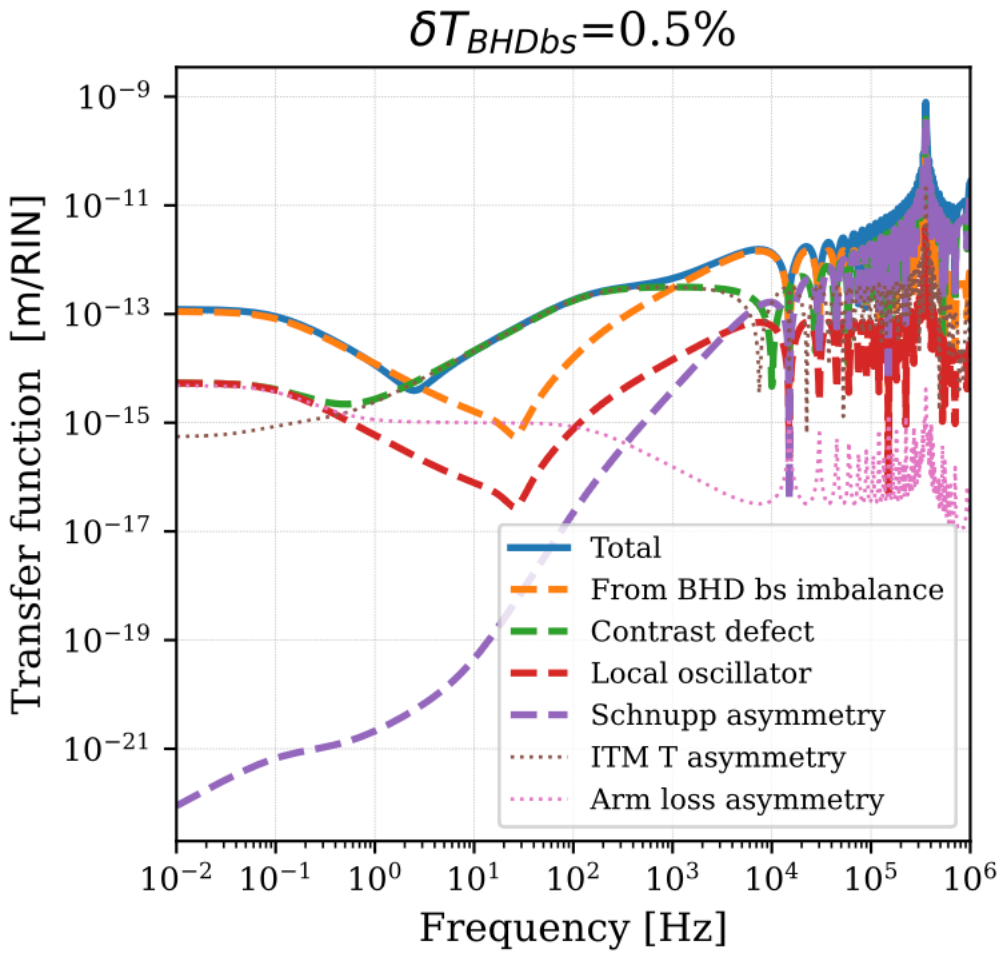


Intensity noise

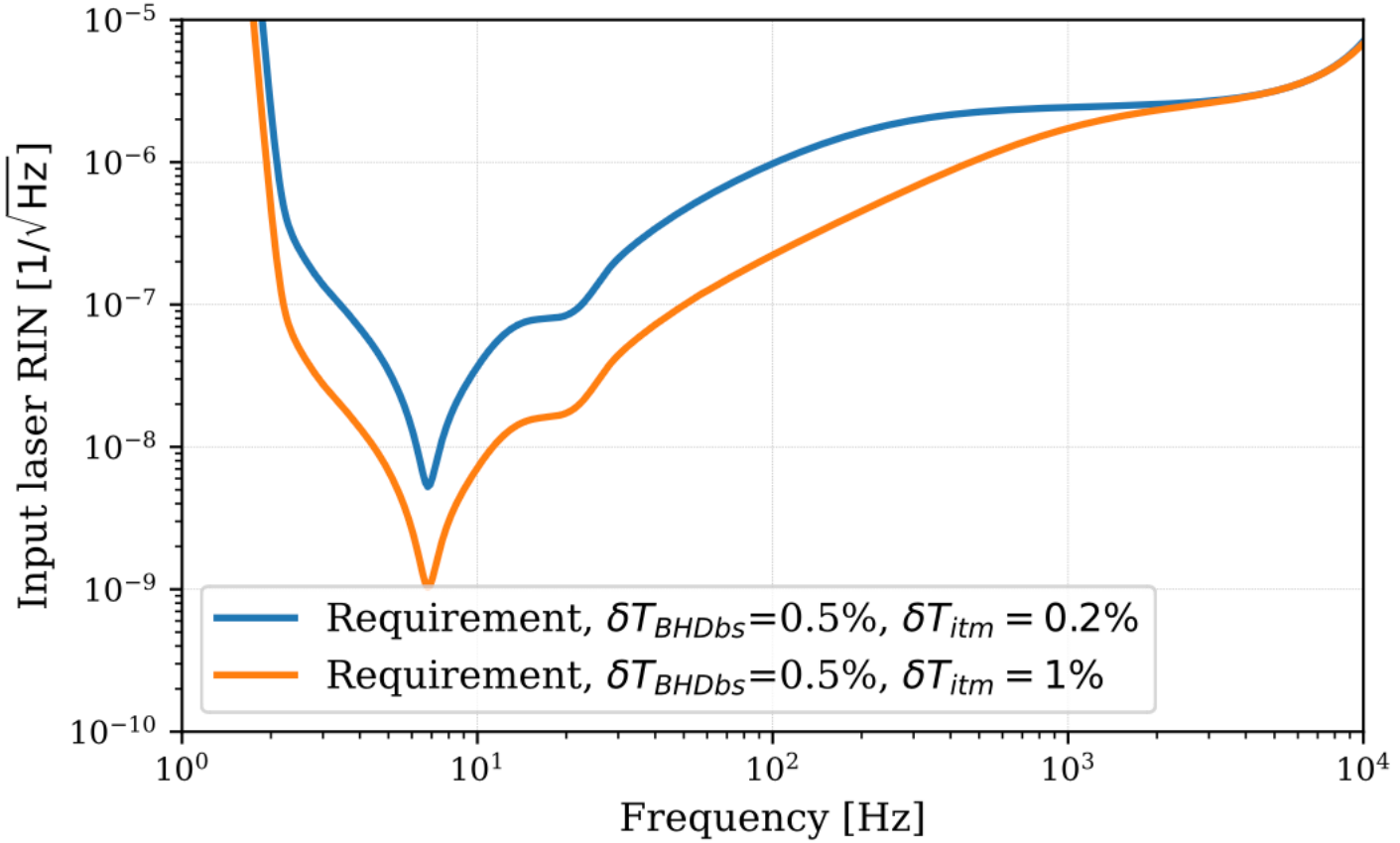
HF

Calibrate intensity noise to equivalent darm motion in $\frac{\mathrm{m}}{\mathrm{RIN}} = \frac{\mathrm{W}}{\mathrm{RIN}} / \frac{\mathrm{W}}{\mathrm{m}}$



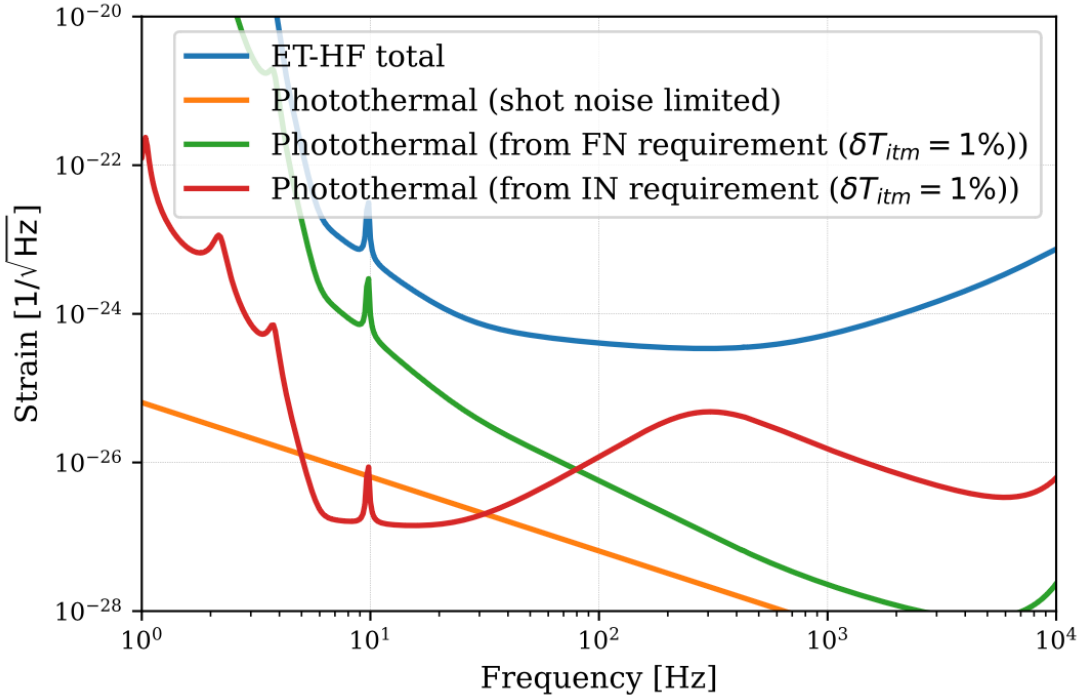


Intensity noise requirement

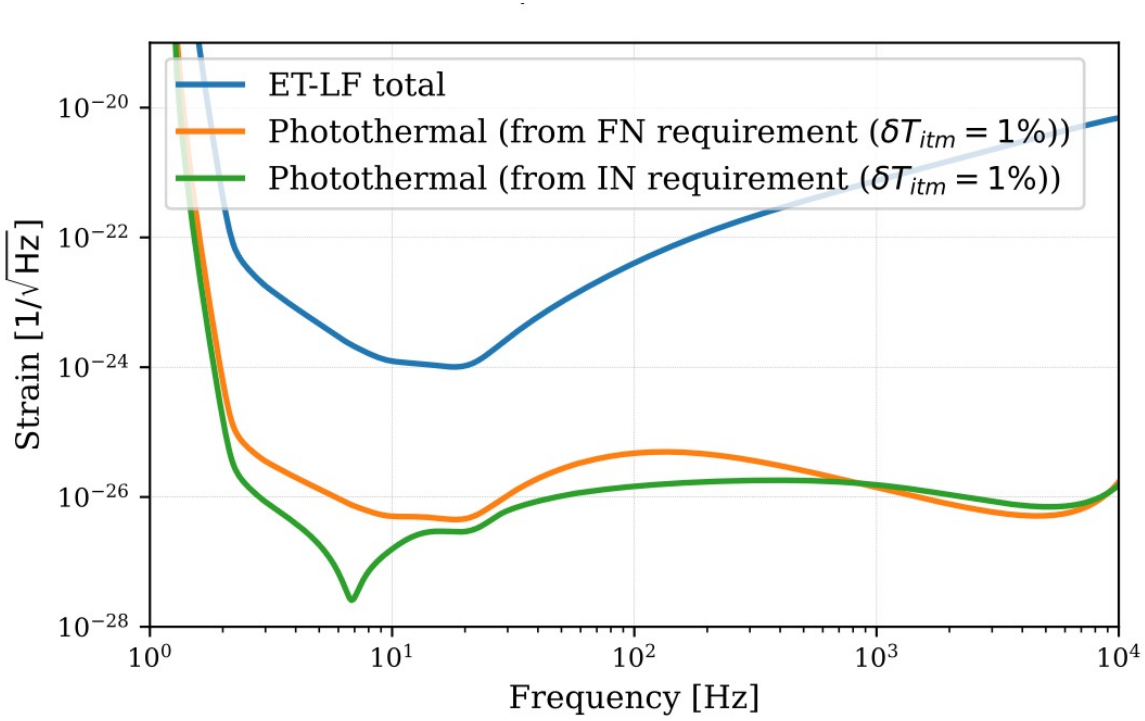


Including a factor of 10 safe margin.

Photothermal noise



Assuming 0.1 ppm absorption



Assuming 5 ppm absorption

Activities at AEI and Artemis

(Debanjan Adhikari , Benno Willke, Marina Trad Nery)

Almost done:

- Analytical calculation (in parallel with Teng) of the laser noise requirements at IFO input
  Cross check our calculation with Teng's one

- Goals: bring intuitive understanding of the TFs and of the requirements to the laser groups
  make a well documented Python code available for the community (good for newcomers)

Future plans:

- Include beam jitter requirements at IFO input

- Laser requirements at PSL-IO interface (in synergy with input optics team) using Finesse