

# laser frequency & intensity noise requirement in ET

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# Beam path in the interferometer

## **Laser noise in signal path:**

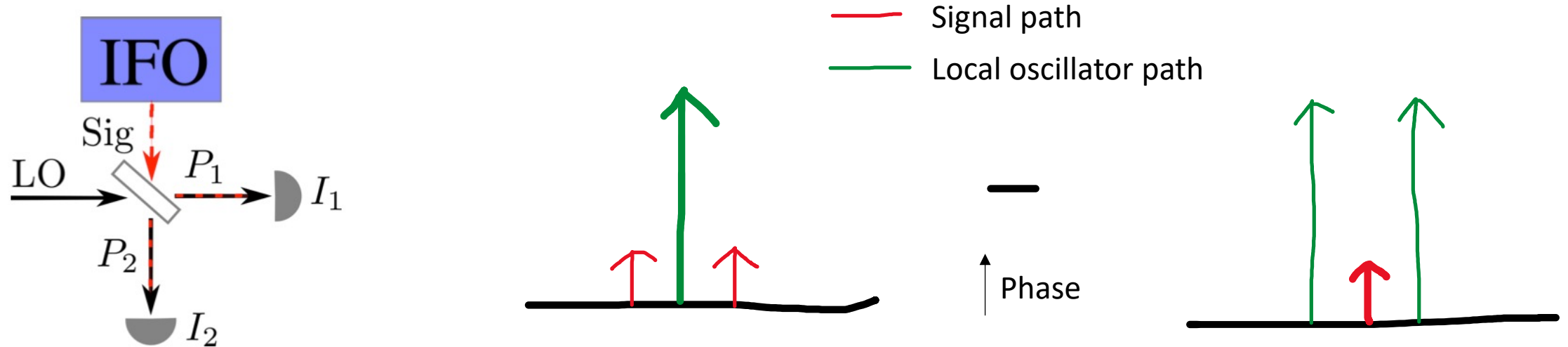
1. Bright port → PRC field , after circulating in coupled PRC-Arm.
2. PRC field → SRC field, due to contrast defect, Schnupp asymmetry.
3. SRC field → dark port, after circulating in coupled SRC-Arm.
4. dark port → readout.

## **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.

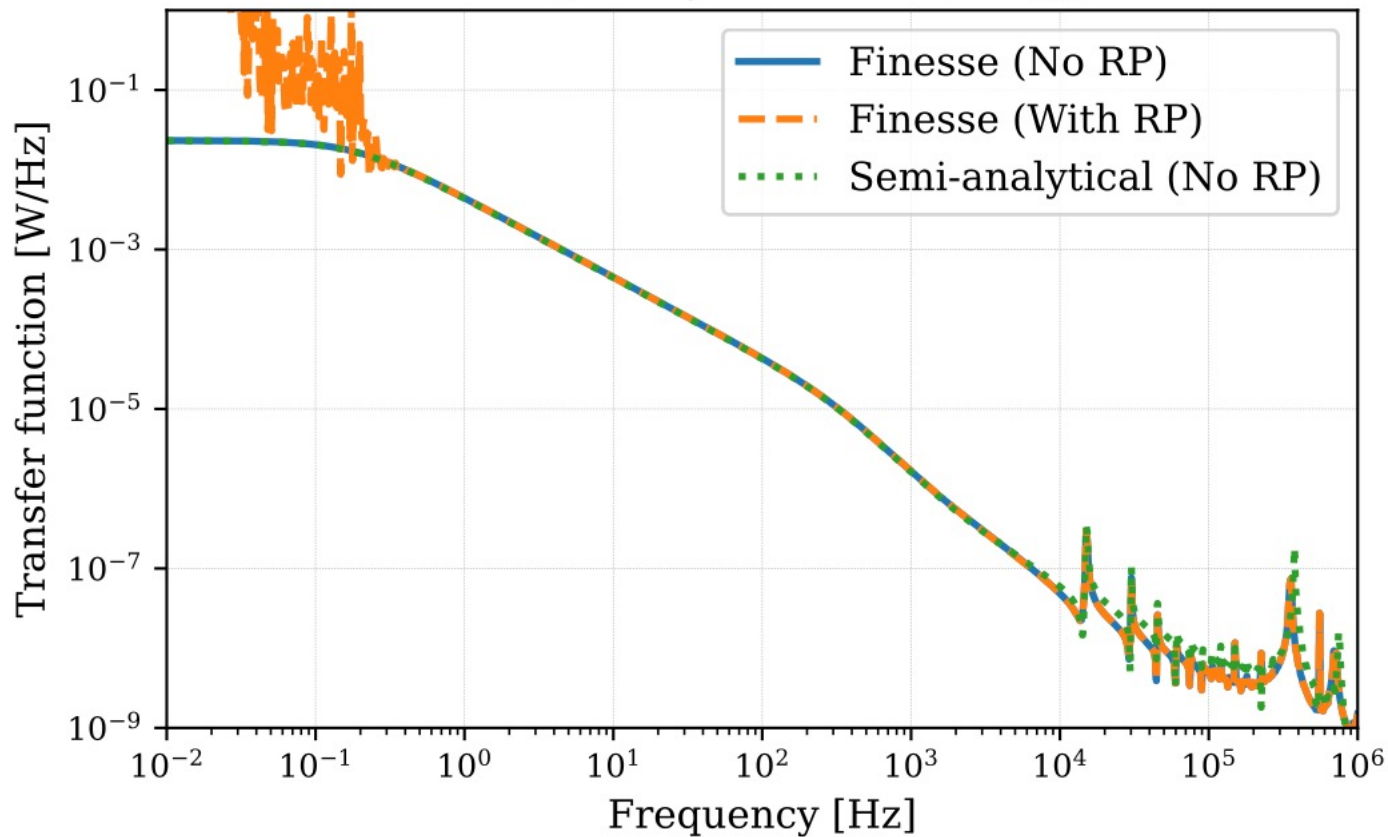
# Parameters

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

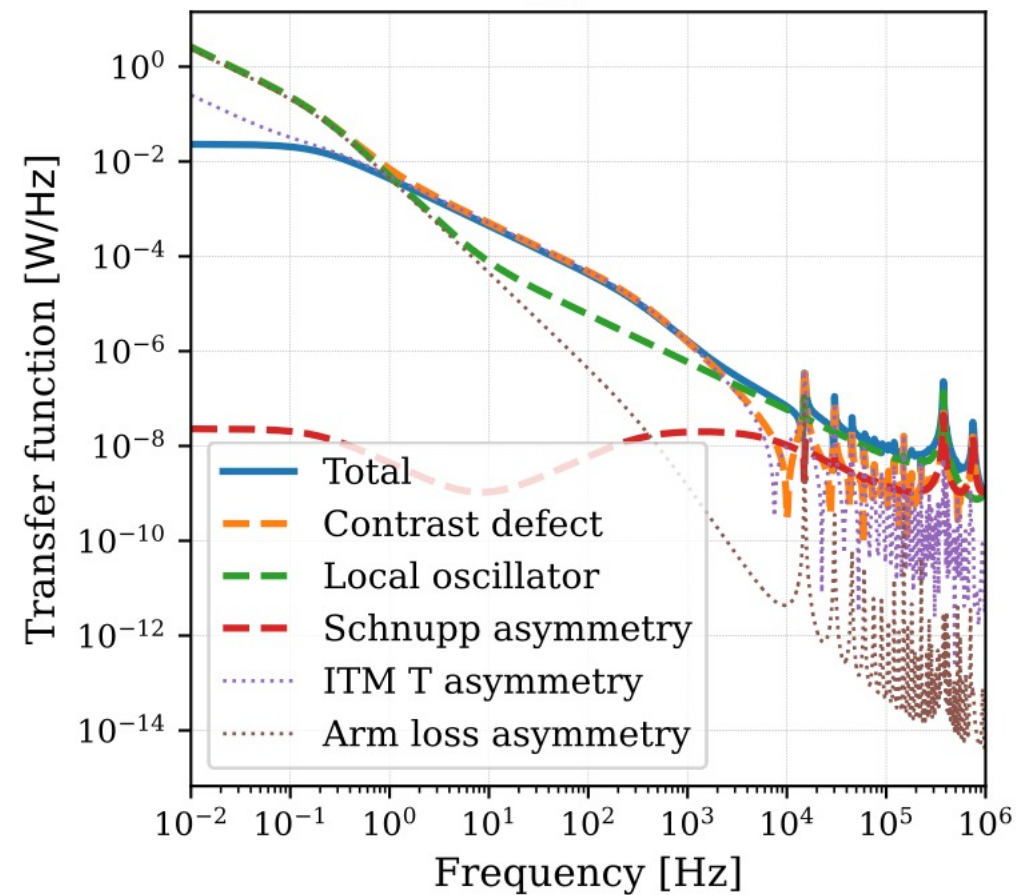
<b>Semi-analytical</b>	
ITM T	0.007
ITM T asymmetry	1%
Mirror loss	37.5e-6
Loss asymmetry	10%
LO power	100mW
Dark port power	1.56mW

## Frequency noise TF in W/Hz

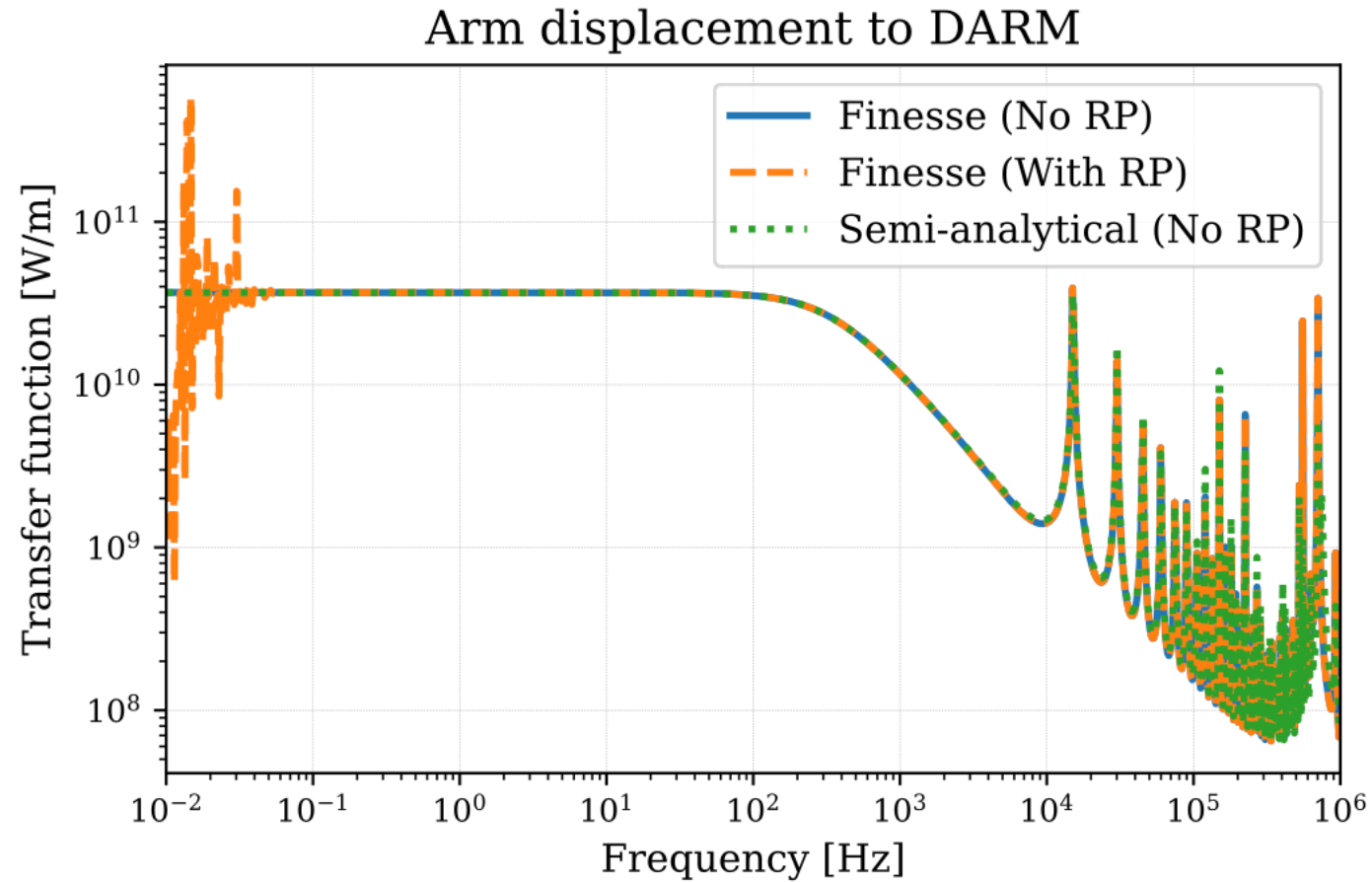
Laser frequency to DARM,  $\delta T_{itm} = 1\%$



$\delta T_{itm} = 1\%$

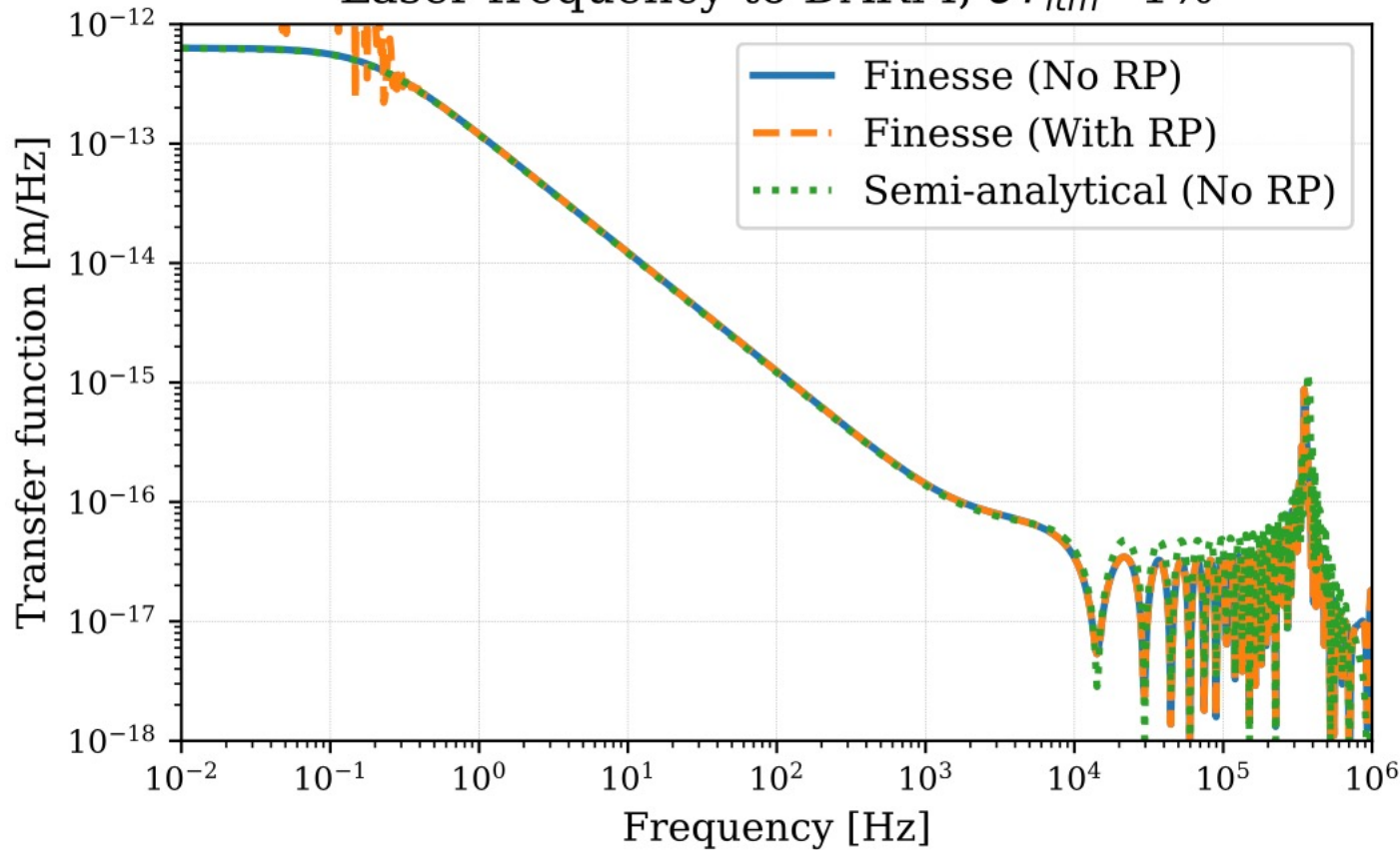


## Darm motion TF in W/m

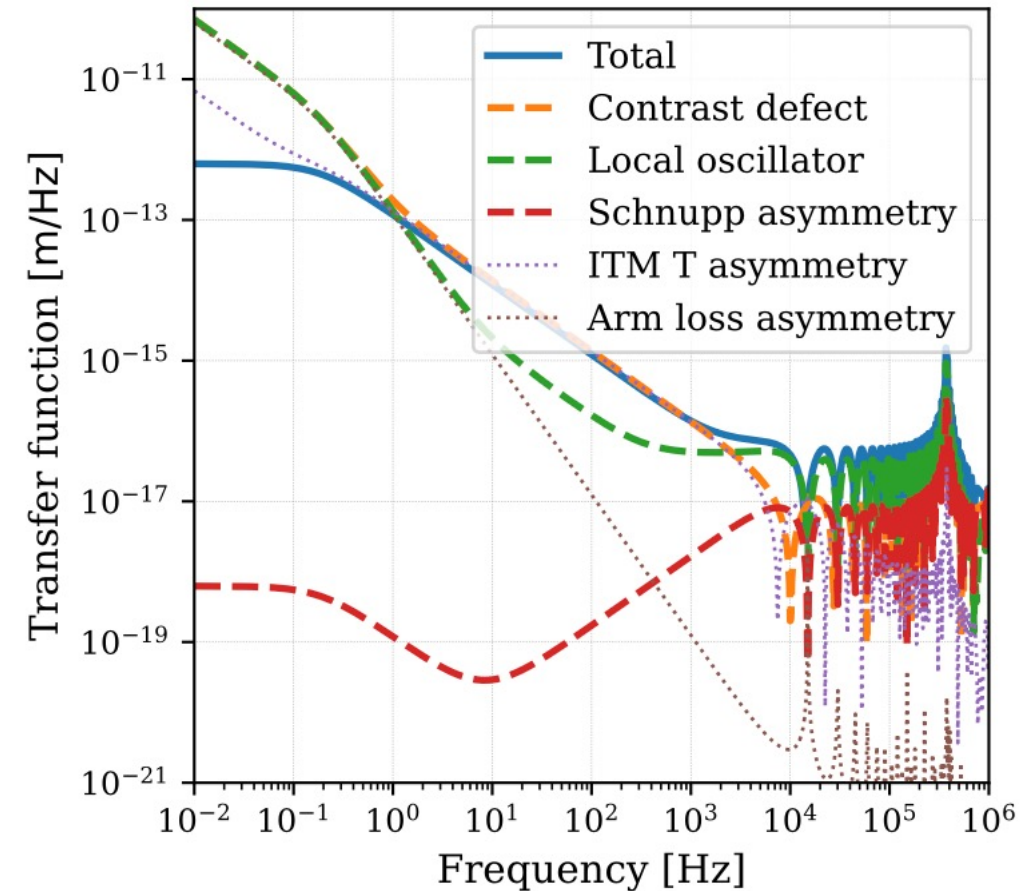


Calibrate frequency noise to equivalent darm motion in  $\frac{m}{\text{Hz}} = \frac{W}{\text{Hz}} / \frac{W}{m}$

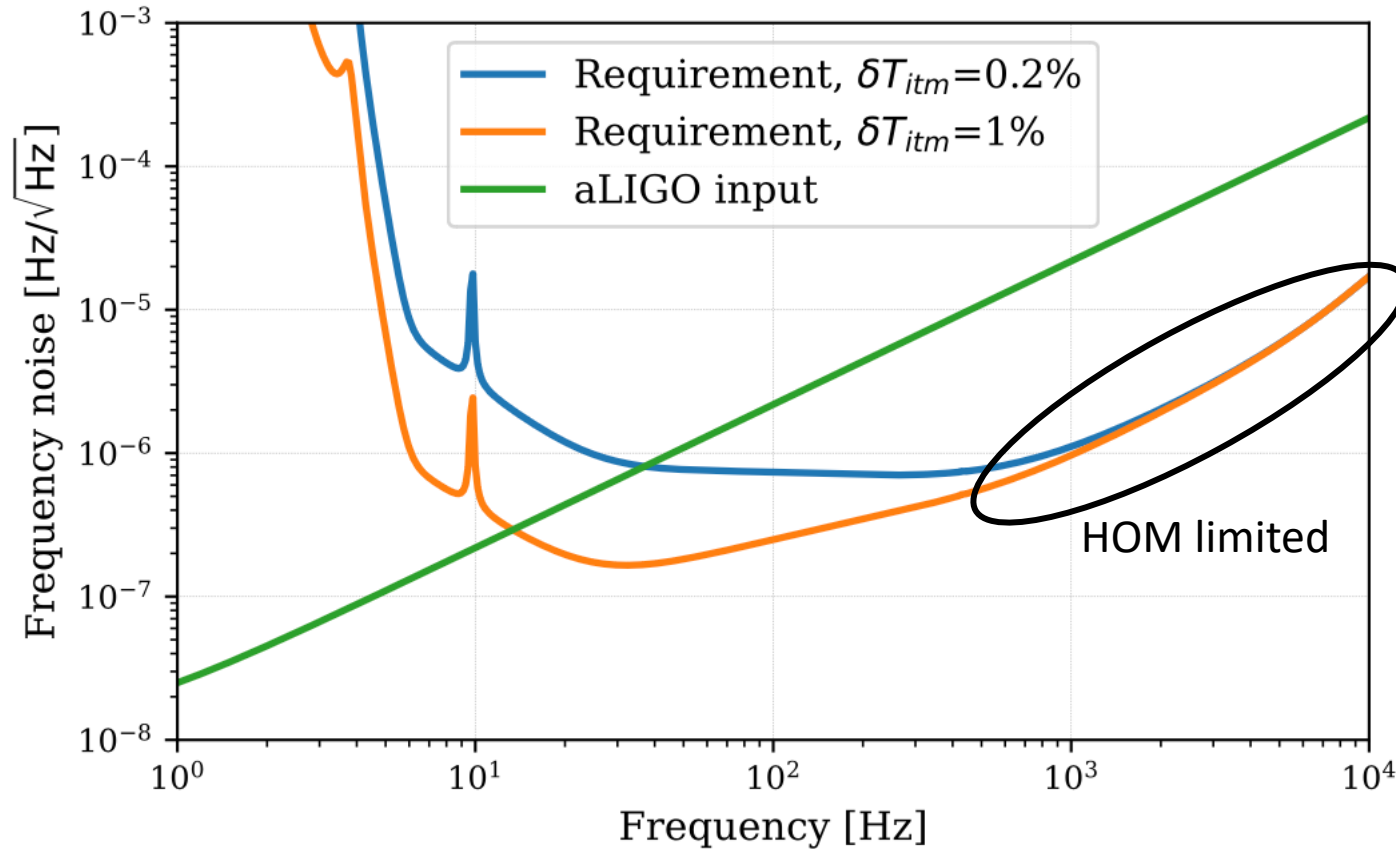
Laser frequency to DARM,  $\delta T_{itm} = 1\%$



$\delta T_{itm} = 1\%$



## Requirement (result from finesse including RP)



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

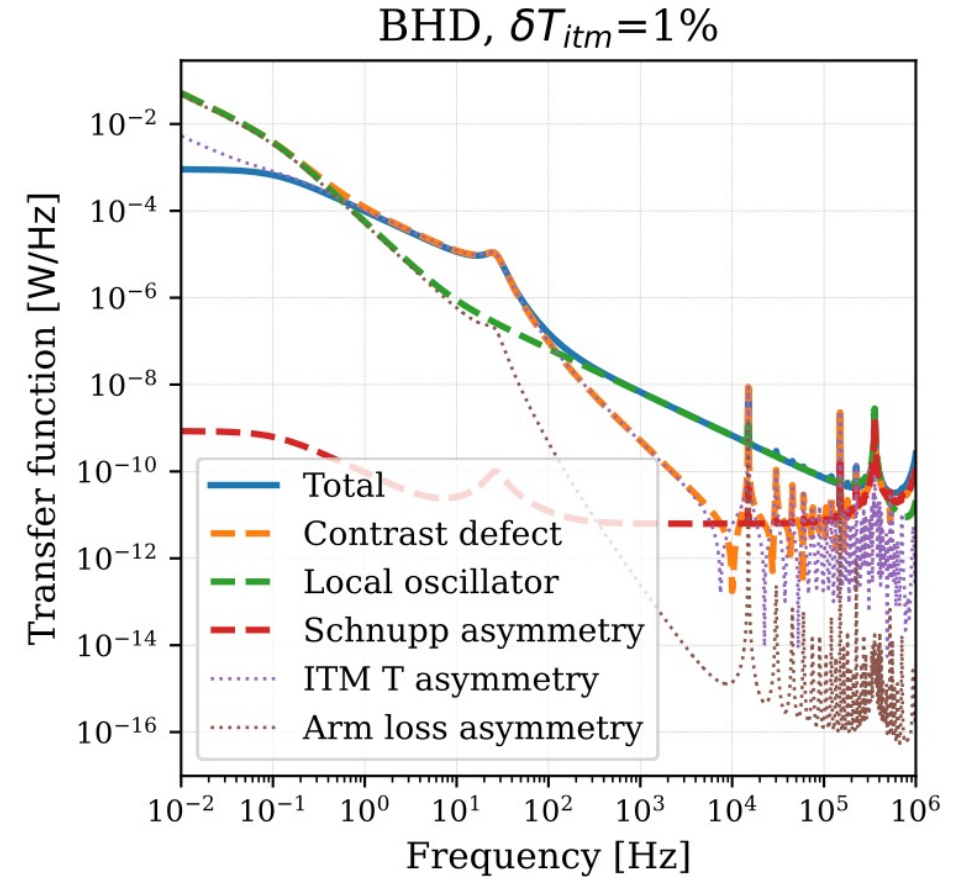
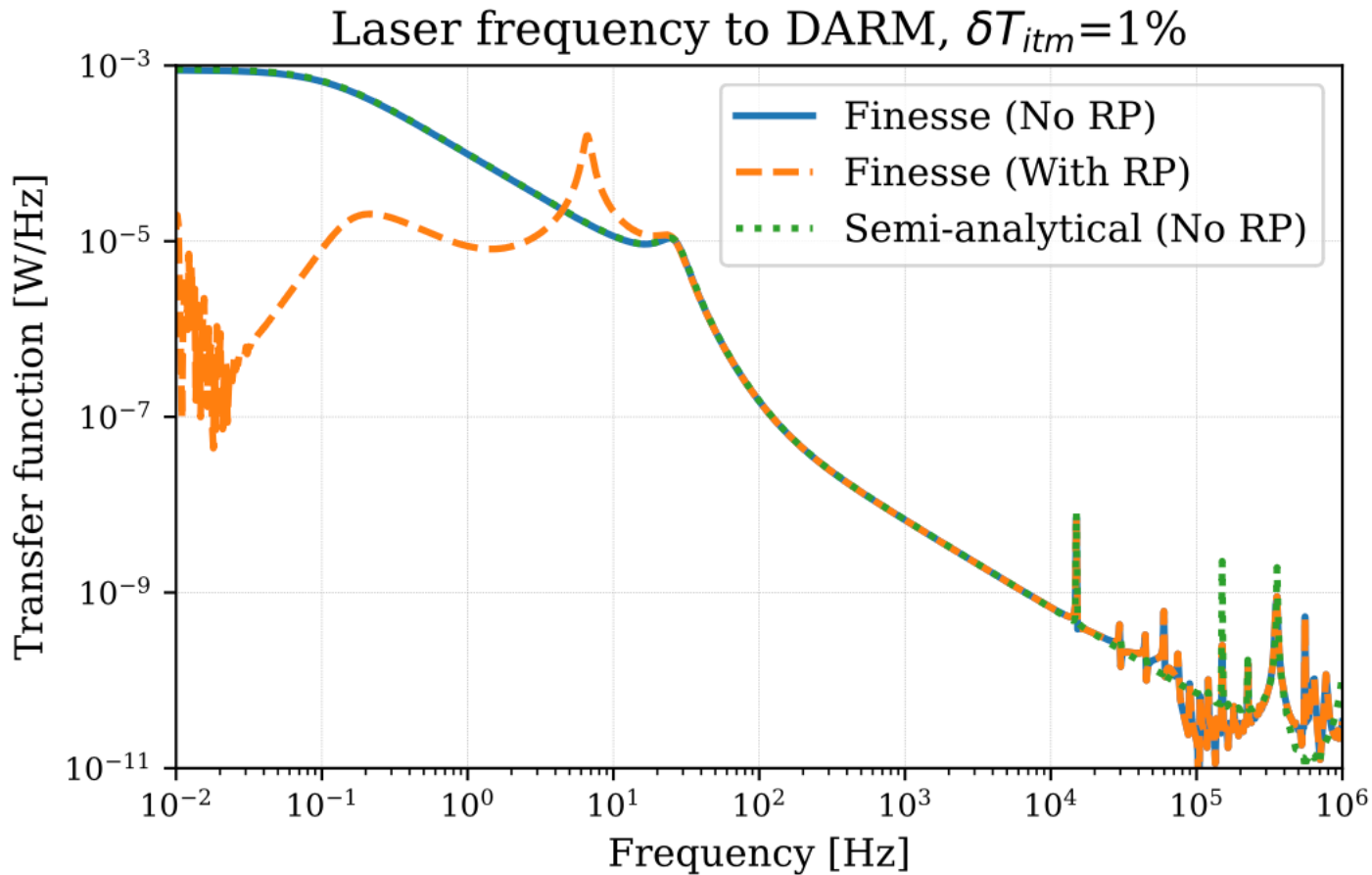


# Parameters

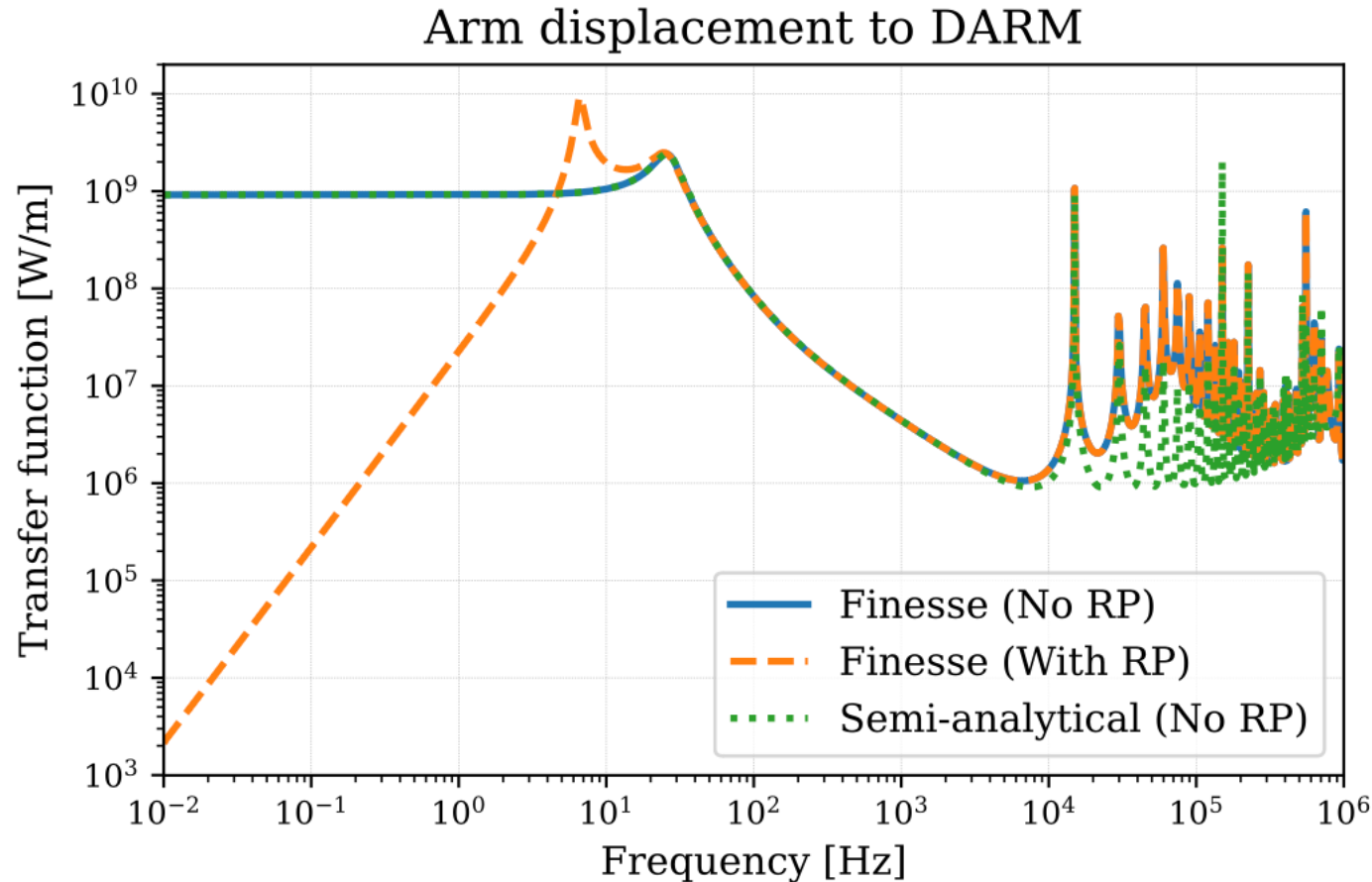
<b>Finesse</b>	
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LO power	10mW
Dark port power	6.34uW

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## Frequency noise TF in W/Hz



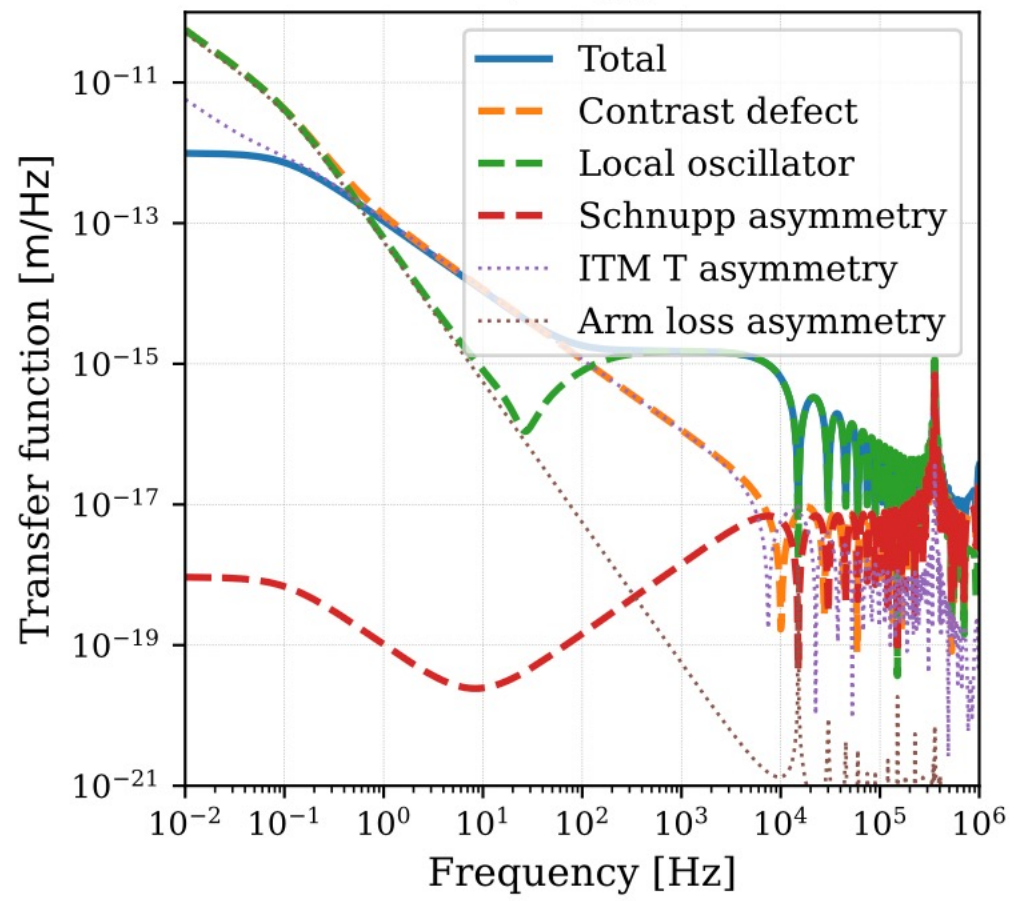
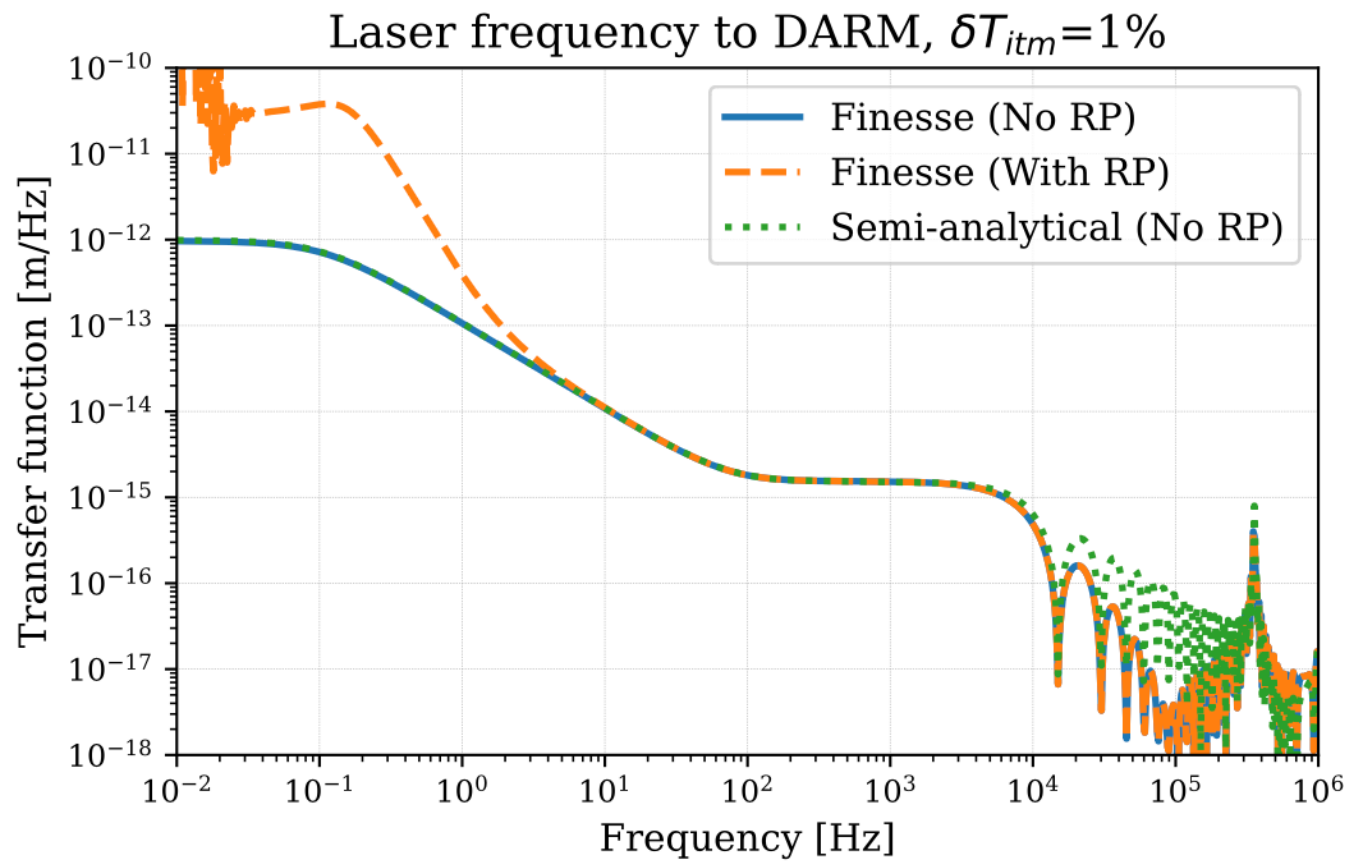
## Darm motion TF in W/m



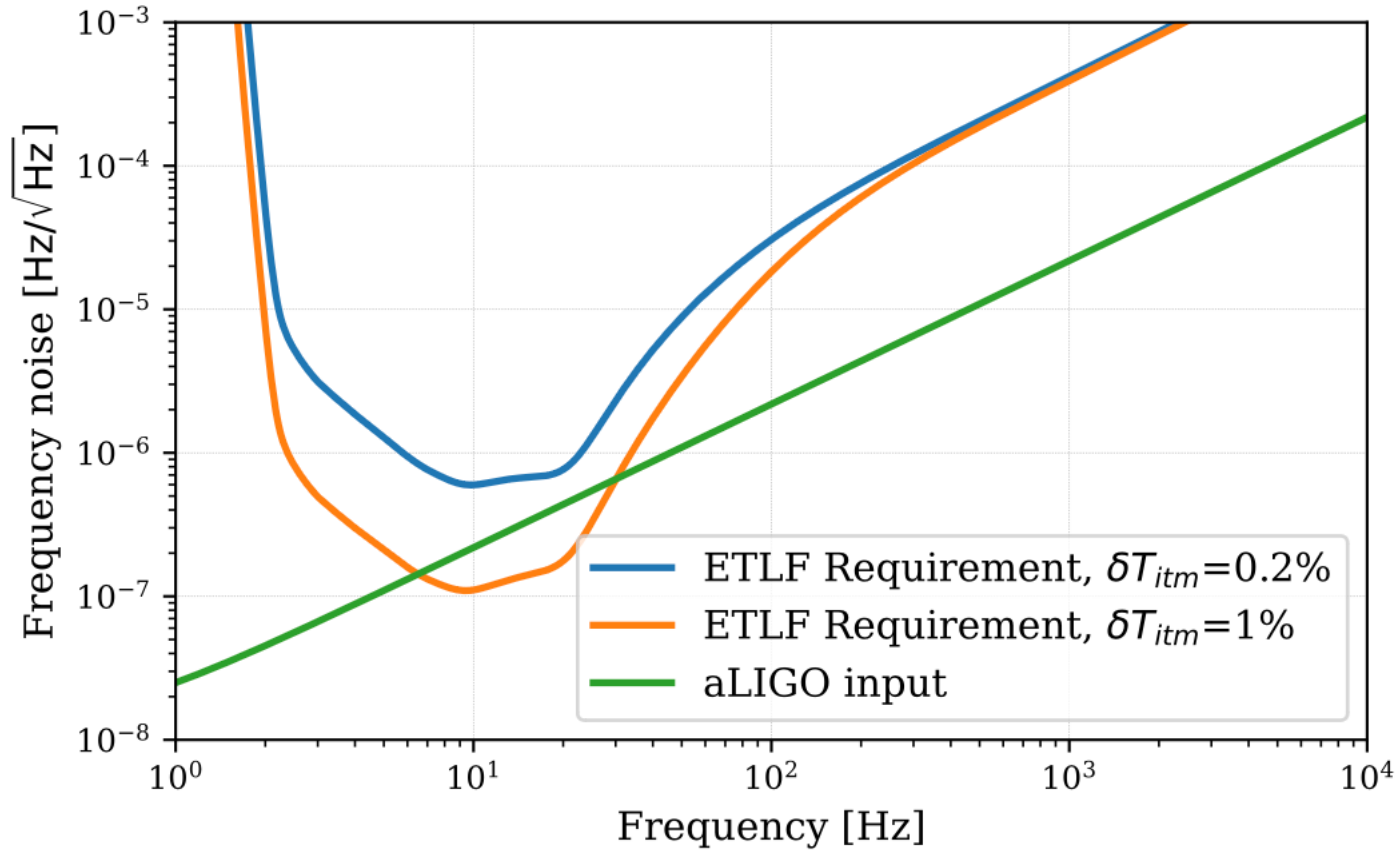
In Finesse, note that to measure the phase quadrature with SRM  $34.2^\circ$  detuned, the LO phase is set to  $-17.2^\circ$ .

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

BHD,  $\delta T_{itm} = 1\%$



## Requirement (result from finesse including RP)



Including a factor of 10 safe margin and  $0.4 \times 10^{-15} \text{m/Hz}$  constant noise from HOM.

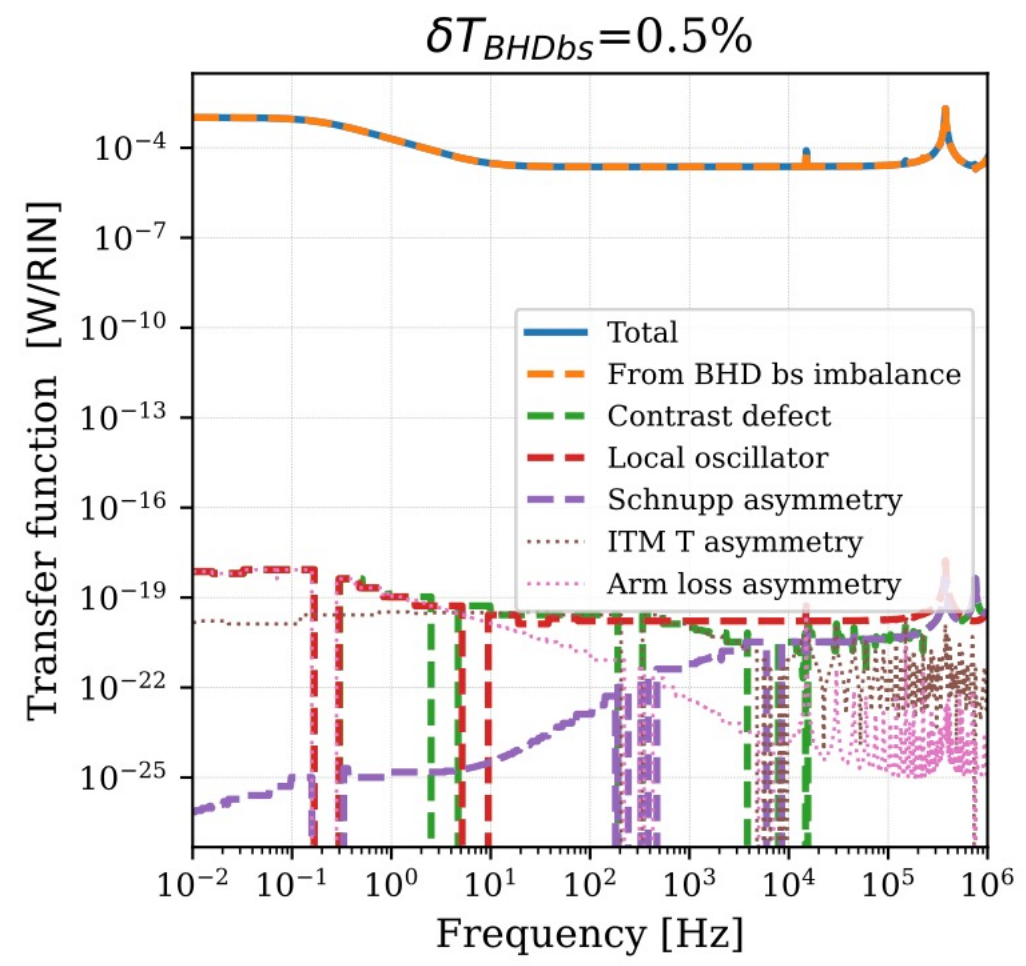
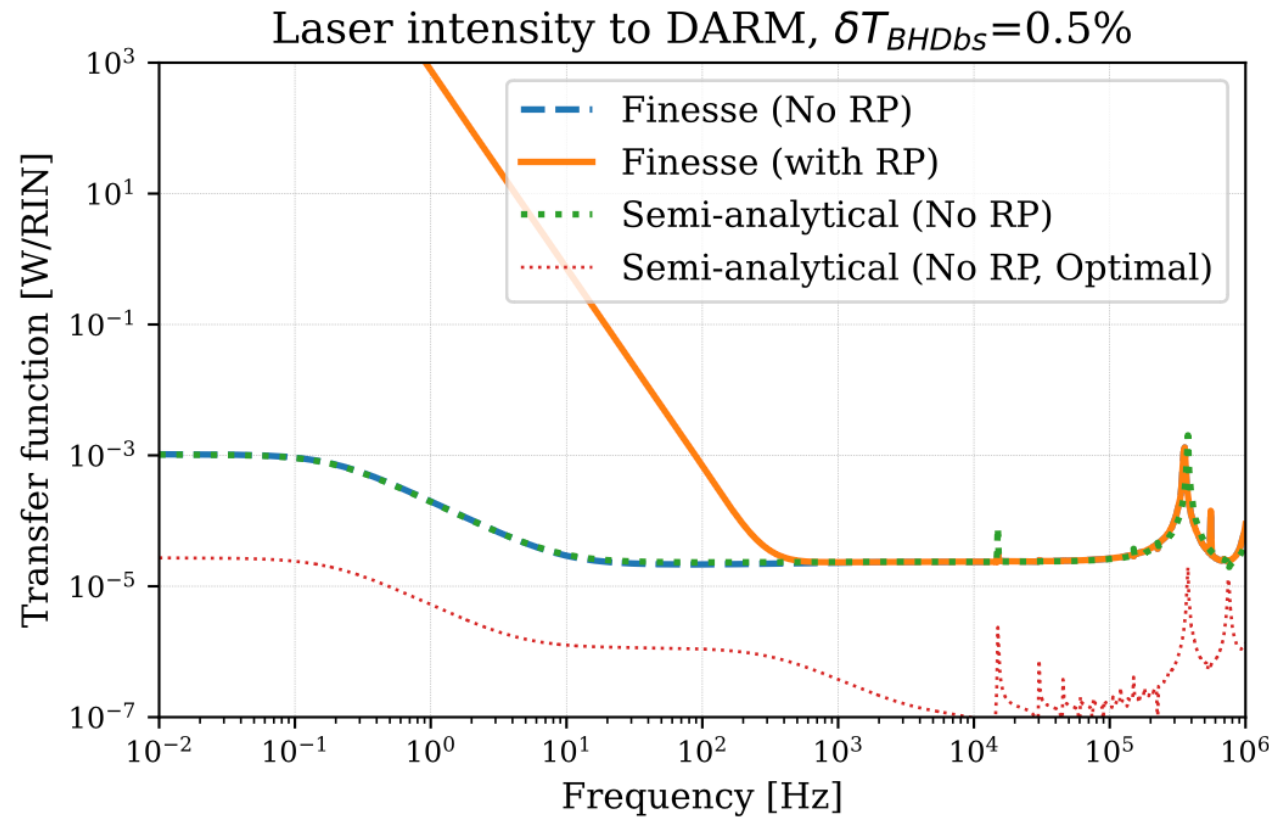
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The LO static field (on phase quadrature) is orthogonal to the amplitude noise in signal beam. Here an imperfection on BHD beamsplitter can introduce the noise from LO itself. : LO static field x the local noise.

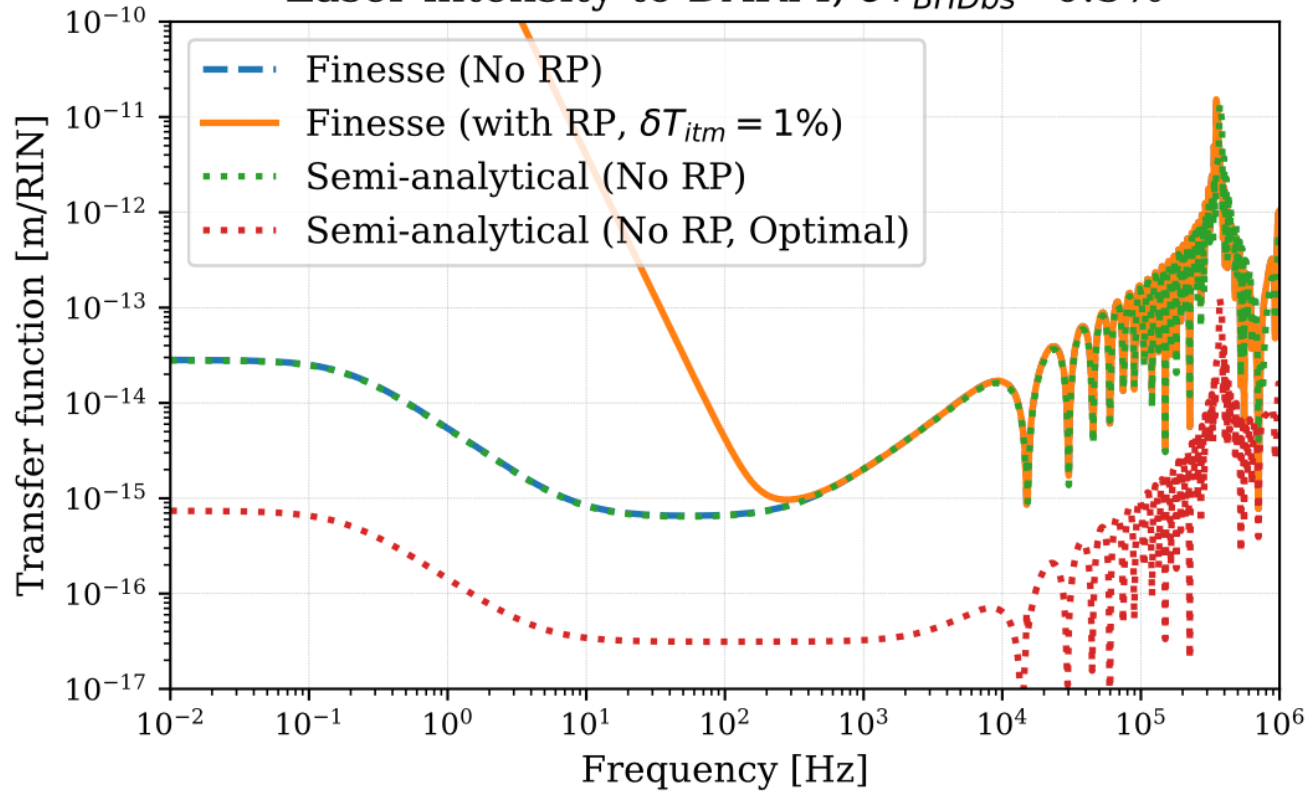
## Intensity noise TF in W/RIN



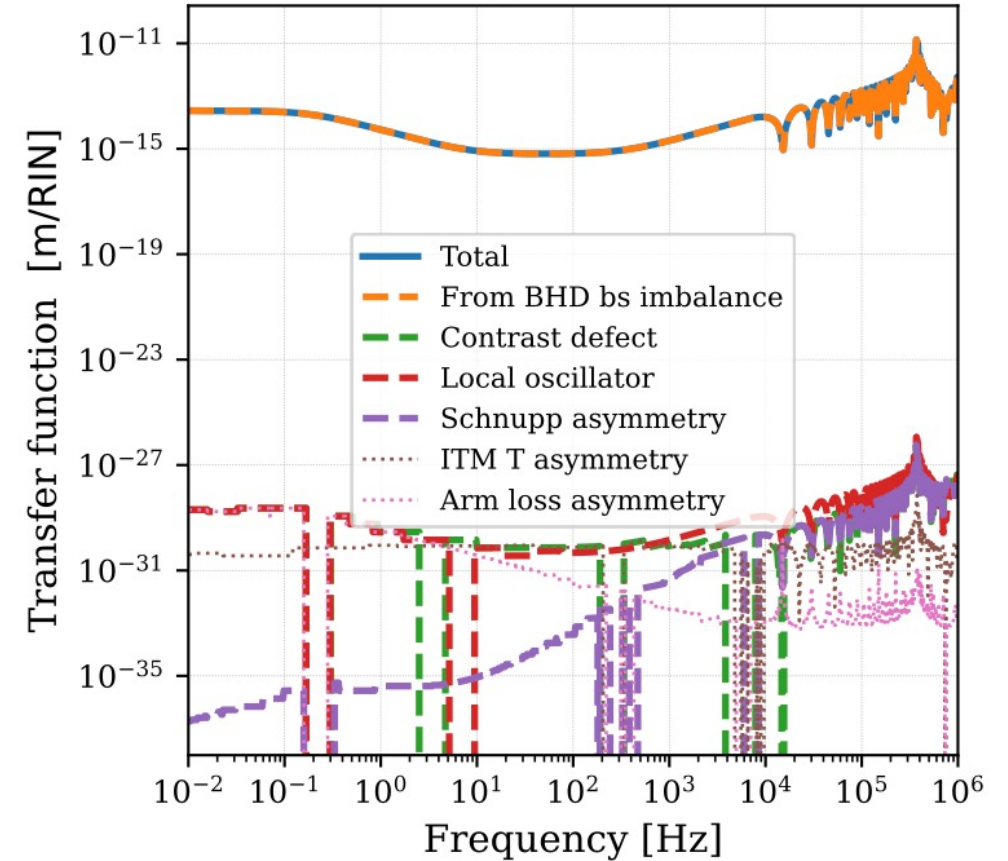


Calibrate intensity noise to equivalent darm motion in  $\frac{m}{RIN} = \frac{W}{RIN} / \frac{W}{m}$

Laser intensity to DARM,  $\delta T_{BHDbs}=0.5\%$

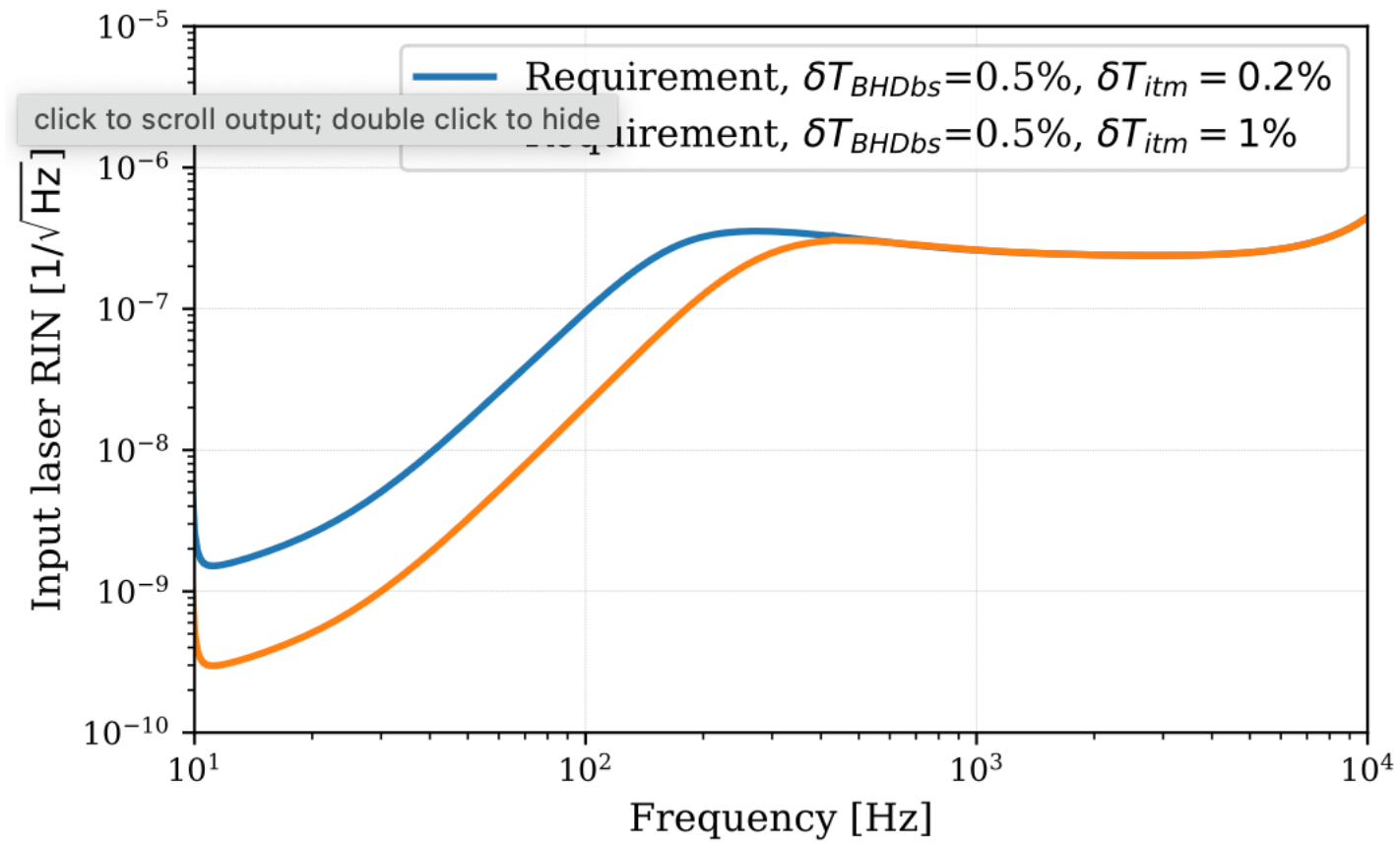


$\delta T_{BHDbs}=0.5\%$





# Requirement



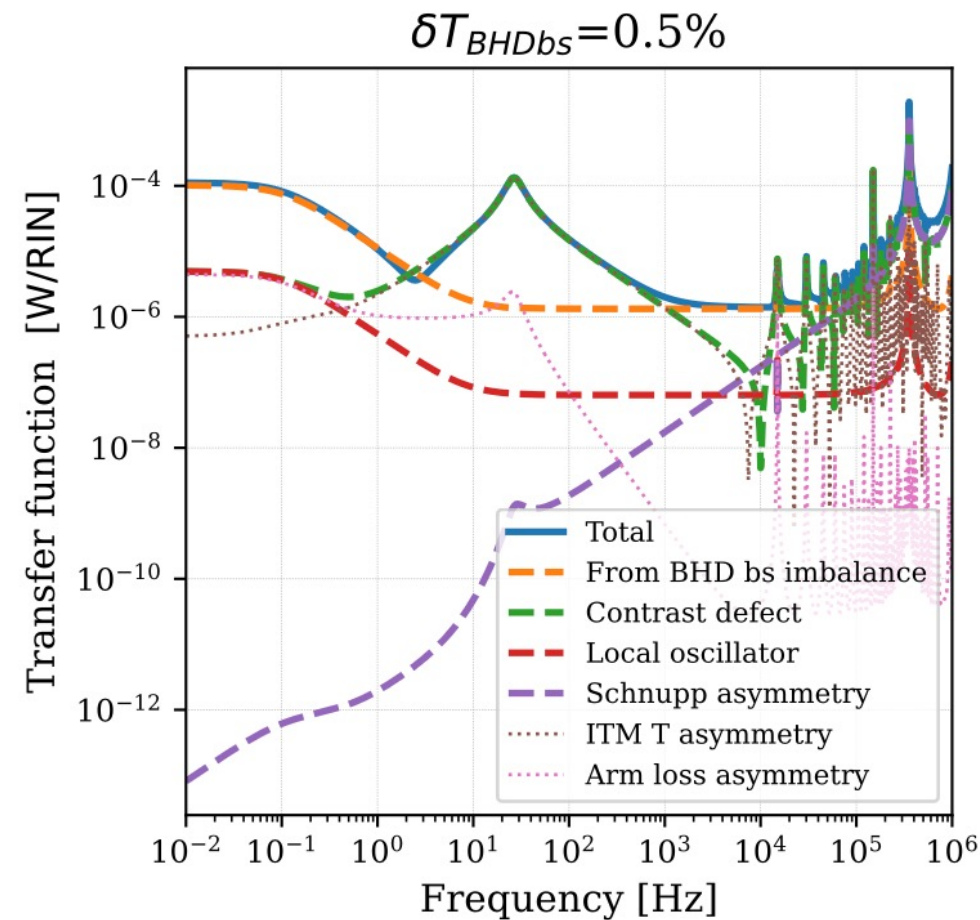
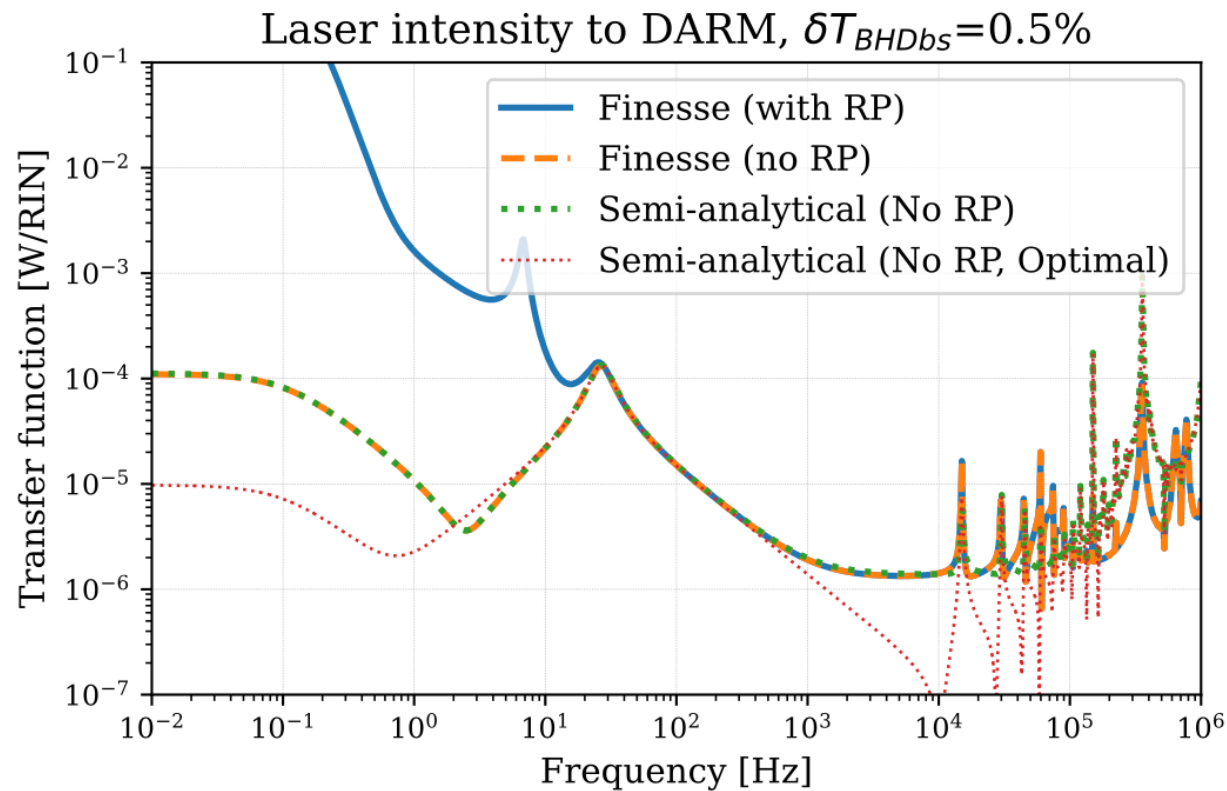
Including a factor of 10 safe margin.

# Parameters

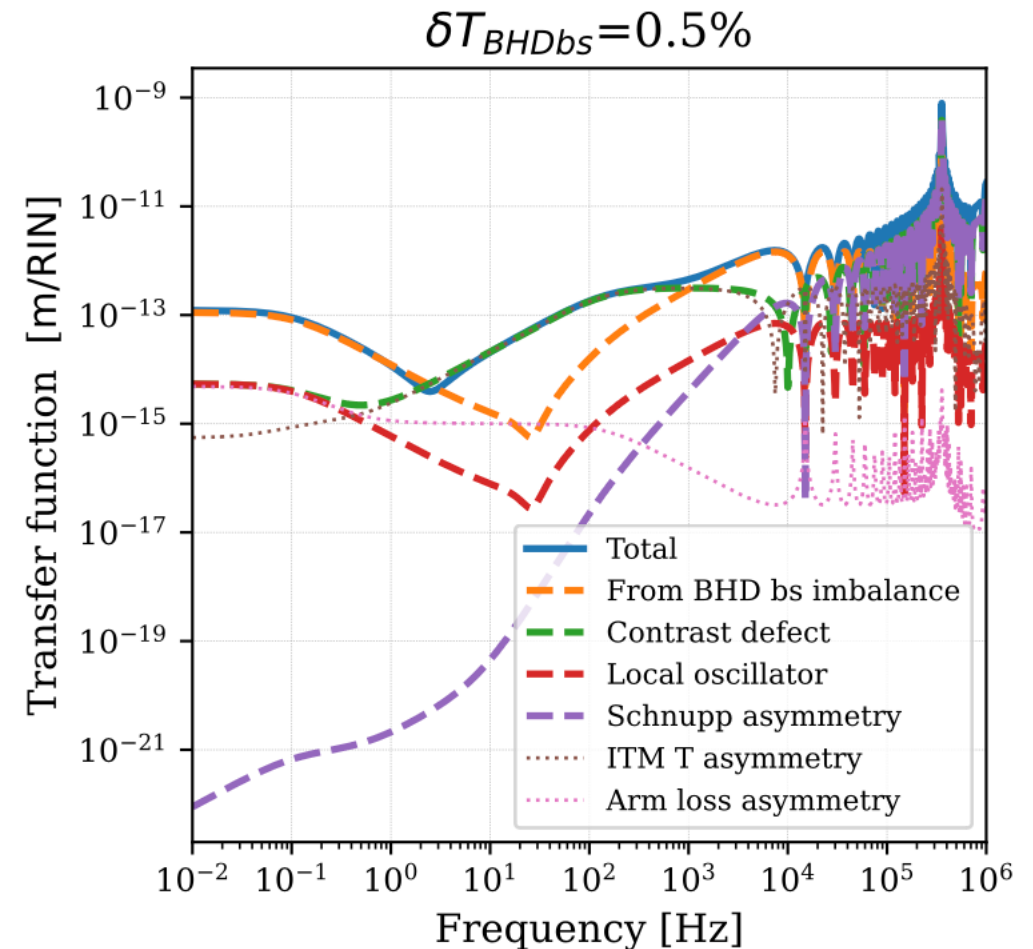
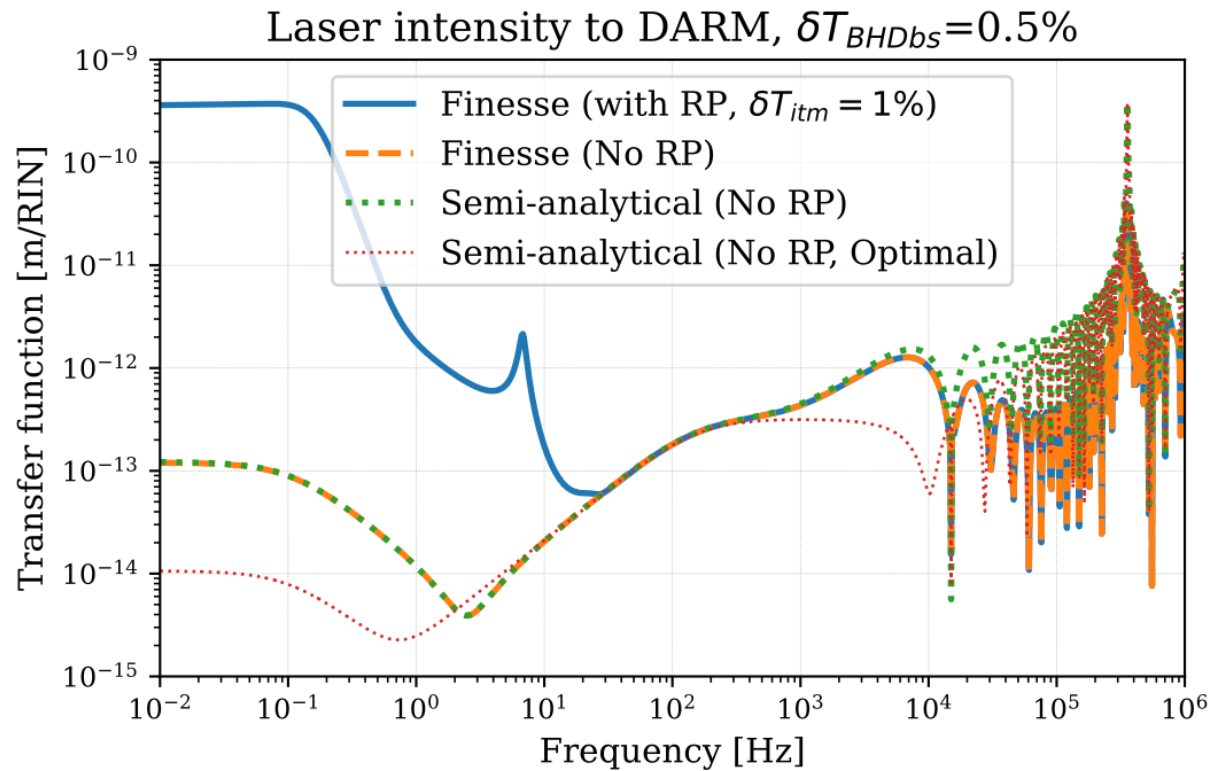
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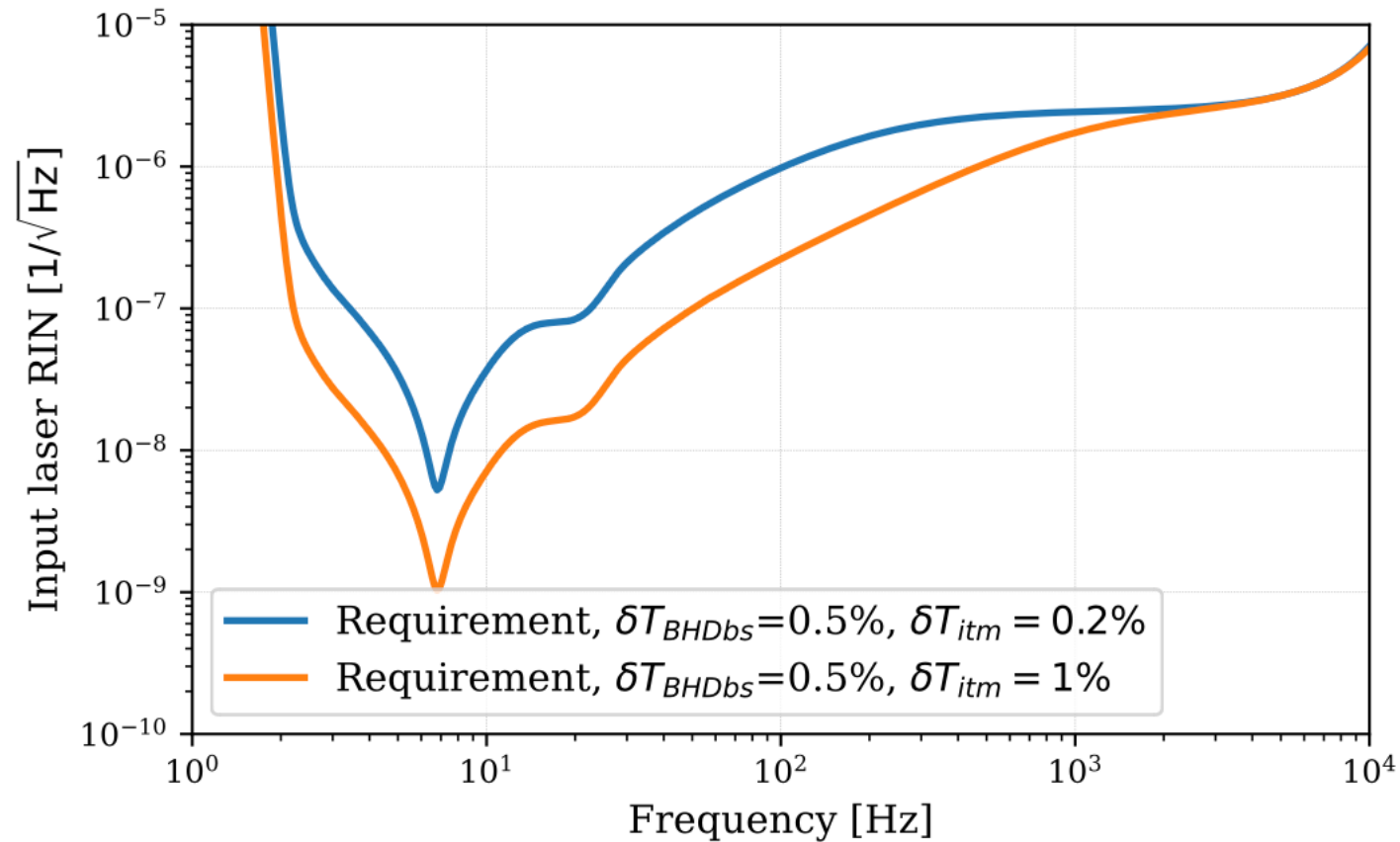
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Calibrate intensity noise to equivalent darm motion in  $\frac{m}{RIN} = \frac{W}{RIN} / \frac{W}{m}$



## Intensity noise requirement



Including a factor of 10 safe margin.

# 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

Thank you!