LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
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Filter Cavity Coatings

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1 Overview

This document is to concisely summarize the parameters for the filter cavity coatings and justify their tolerances. Note that the mirrors here are labeled FC1 and FC2 as designated in the layout drawings and assigned for the suspensions; however, the substrate, coating and polish documents use FIM (Filter Cavity Input Mirror) for FC1 and FEM (Filter Cavity End Mirror) for FC2.

- FC1 Surface 1 at 1064nm: 0.001 $\pm$5% Transmissivity HR
- FC2 Surface 1 at 1064nm: 2-4 ppm Transmissivity HR

The transmissivity of the input mirror FC1 is determined by running GWINC and optimizing the range as a function of the squeezing level and transmissivity. These are shown in Figures 1 and 2. For the 85W operating power, the chosen transmissivity is optimal, and the range is a relatively weak function of the input power. This transmissivity corresponds to a cavity pole of 39.8Hz ideally and 42Hz with 60ppm of losses. The tolerances are set to be a relative error of 5% in the transmissivity. This will change the optimal operating point, but not severely impact the range. The transmissivity of the endmirror is chosen to be subdominant to scattering, but nonzero. Experience with the R&D filter cavity indicates that the transmission signal is useful even in operation. This range of transmissivities will cause the resonant cavity transmission to be 0.7% $\approx 4 \cdot 2{\cdot}10^{-6}/1{\cdot}10^{-3}$ to 1.5%. This transmissivity is sufficient to be useful for backup in-air LSC or ASC sensing in transmission.

- FC1 Surface 1 532nm: 0.01 Transmissivity HR with 5% relative error
- FC2 Surface 1 532nm: 0.01 Transmissivity HR with 5% relative error

This transmissivity will make a critically coupled cavity at 532. This is optimal for RF sensing in reflection and DC sensing in transmission. The cavity pole will be 800Hz, easy to acquire lock with the 532 frequency servo. Tolerances are set so that mismatch doesn't overly ruin perfect critical coupling. At 5% mismatch with one mirror high and the other low, the cavity locked reflectivity will 0.25 % in power. It can reach shot-noise limited sensitivity if the RF sideband modulation index is above 0.05 in the worst-case. At 532 we anticipate that the cavity will be limited by acoustic phase noise on the input sensing field, not shot noise.

All of the surface 2 coatings will be AR. As with 1064, the tolerances at 532 can be relaxed compared to 1064 if needed to meet or improve the 1064 specifications.

2 Figures

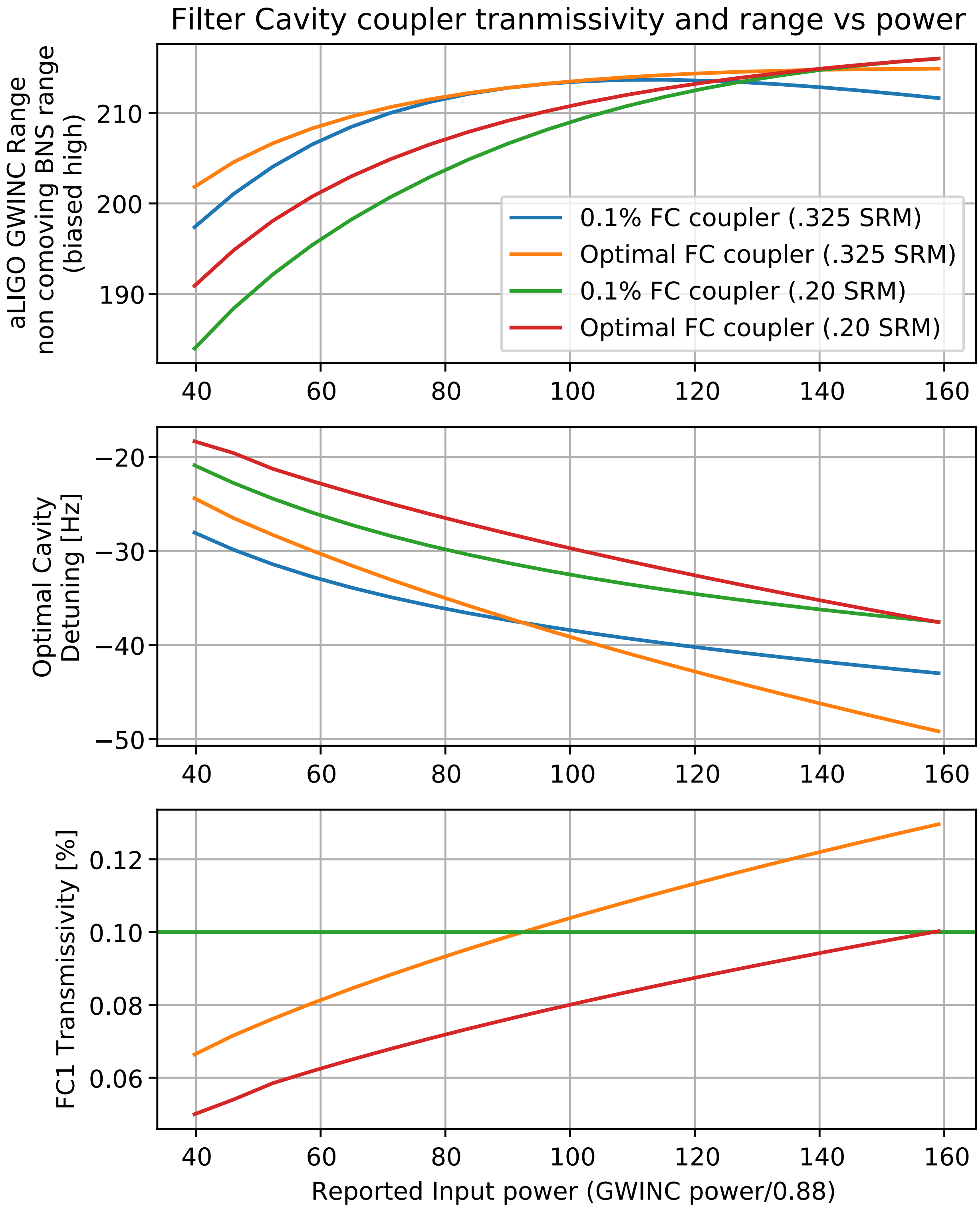

Figure 1: GWINC range calculation with the filter cavity and squeezing parameters optimized at each injected power. This uses 60ppm of round-trip loss in the cavity.

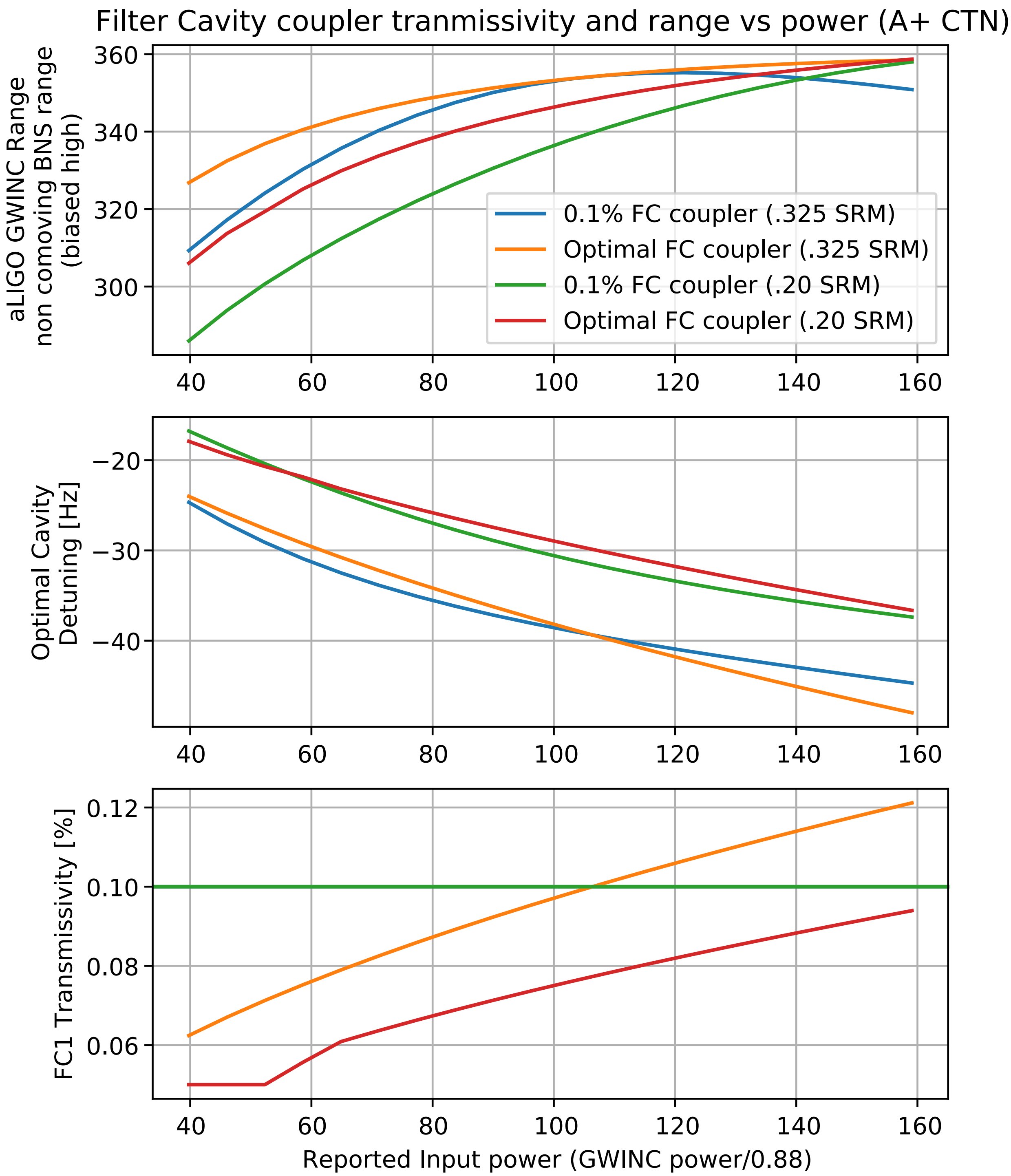

Figure 2: GWINC range calculation with the filter cavity and squeezing parameters optimized at each injected power. This plot uses the coating thermal noise assumed for A+, showing that optimum is not a function of the background noise. This uses 60ppm of round-trip loss in the cavity.