

# LIGO as it goes from cold to hot state

## E2E simulation studies

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LSC meeting, LLO

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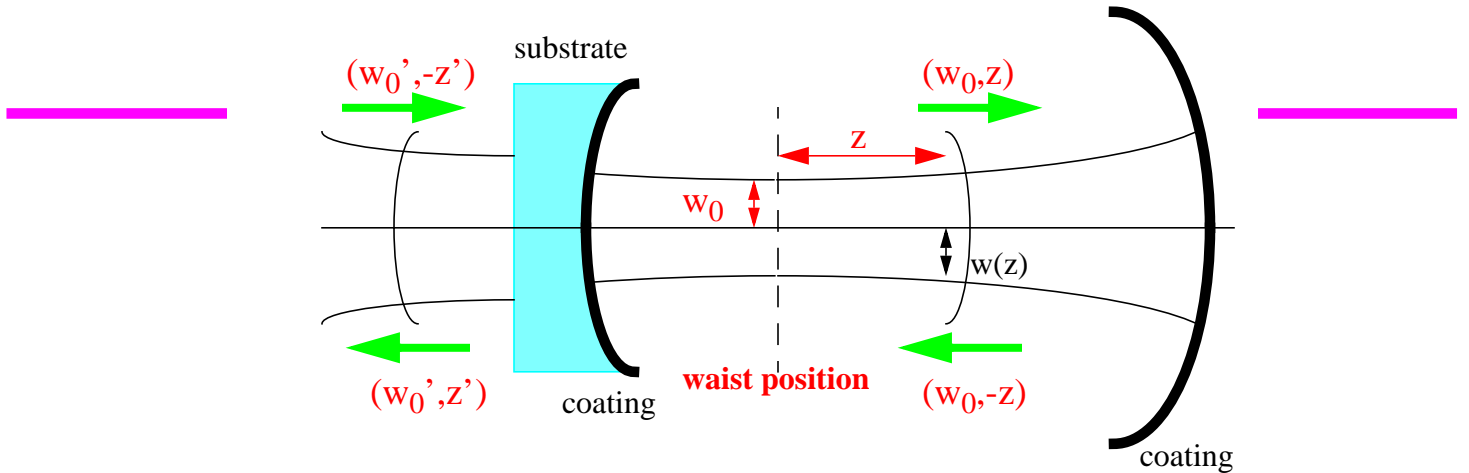
LIGO, Caltech

- Other contributors: Matt Evans, Hiro Yamamoto

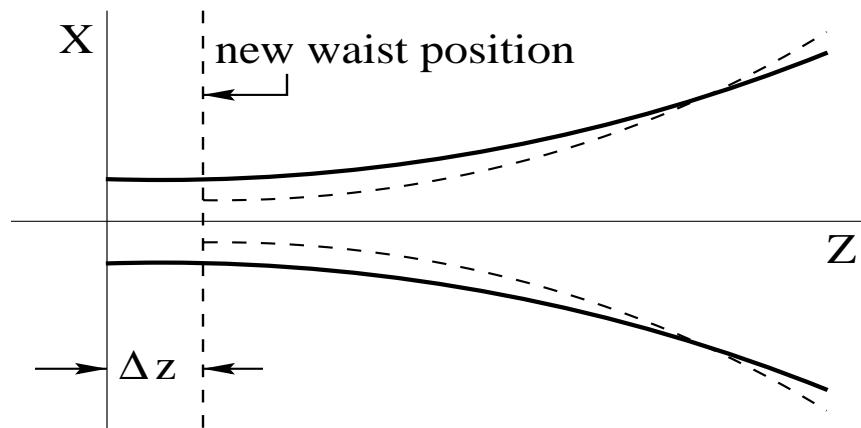
# Final Aim

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- To see if LIGO remains locked as it goes from a cold start to a hot state which gives rise to the thermal lensing problem...and ,if not, to find out the changes needed to keep it locked

# Mode Mismatch



- >> Modal basis : waist-size, dist-to-waist
- >> Mode mismatch



- >> Corresponding reduction in the coupled TEM00 power

$$\left\langle \frac{\Delta P}{P} \right\rangle = \left( \frac{w_0'}{w_0} - 1 \right)^2 + 2 \times \left( \frac{1}{2\sqrt{2}} \frac{\Delta z}{z_0} \right)^2$$

- >>  $Z_0$  (Rayleigh range) is  $\sim 3000$  meter in LIGO arms

# perturbation effects

(ref: Anderson, 1984)

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- Initial beam :  $k$  - mode no. ;  $w$  - waist

$$AU_0$$

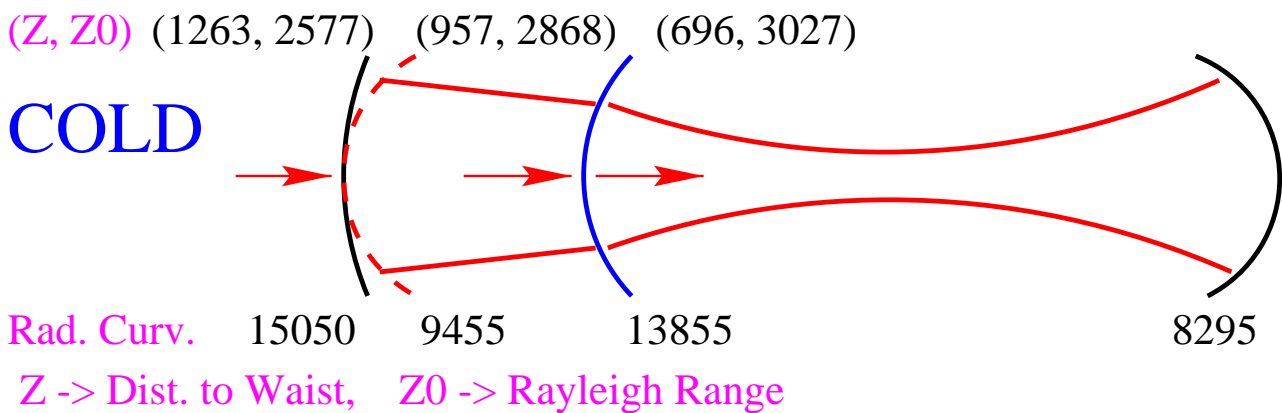
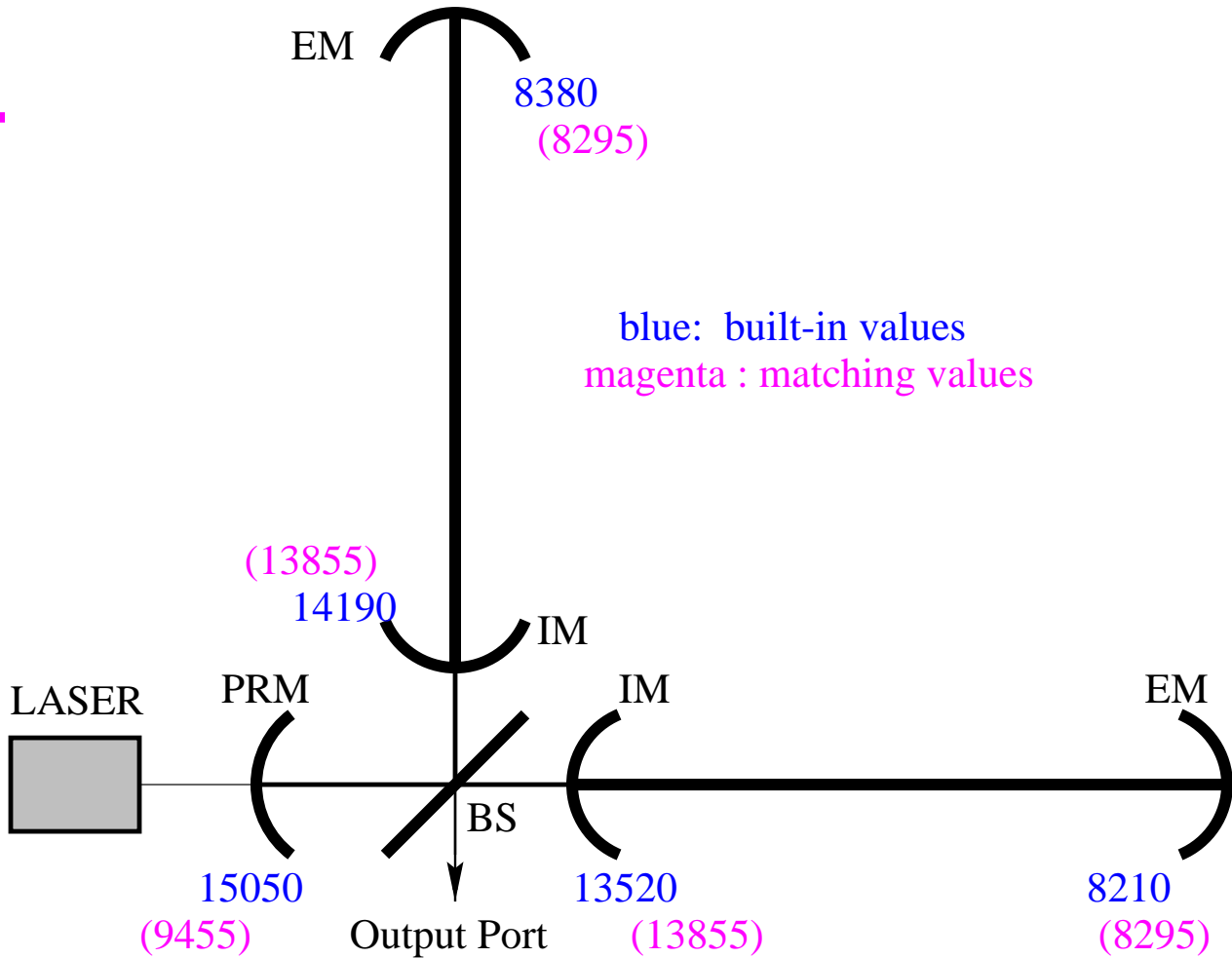
- Waist-position mismatch ( $b$ ) :

$$A \left[ U_0 + j \frac{b}{2kw^2} \{ U_0 + U_2 \} \right]$$

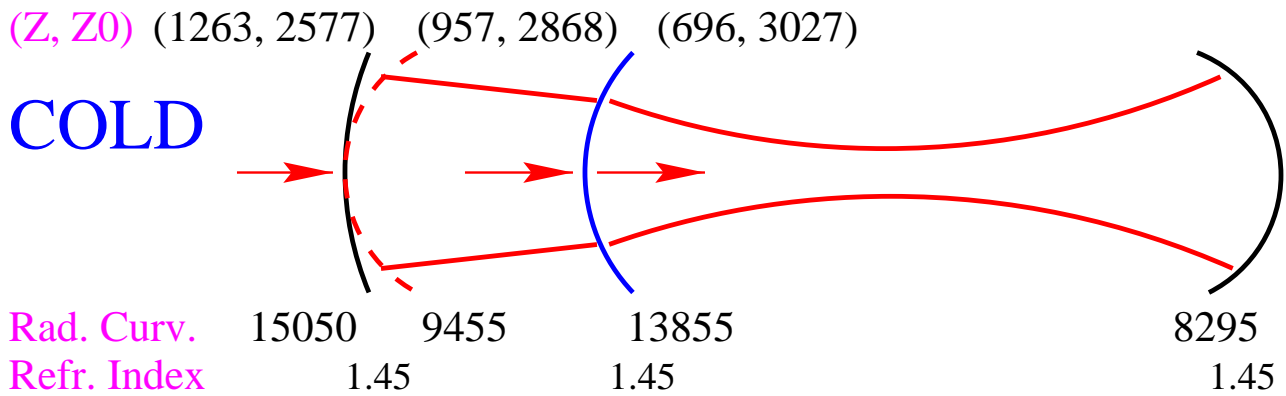
- Waist-size mismatch ( $s$ ) :

$$A \left[ U_0 + \frac{s}{2w} U_2 \right]$$

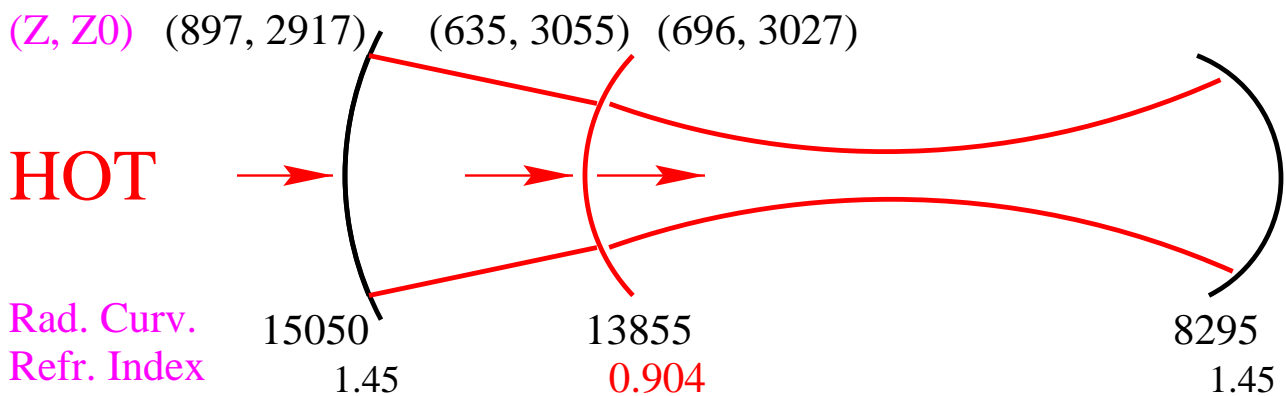
# LIGO Interferometer



# Han2k: Cold & Hot states



$Z \rightarrow$  Dist. to Waist,  $Z_0 \rightarrow$  Rayleigh Range



# Procedure

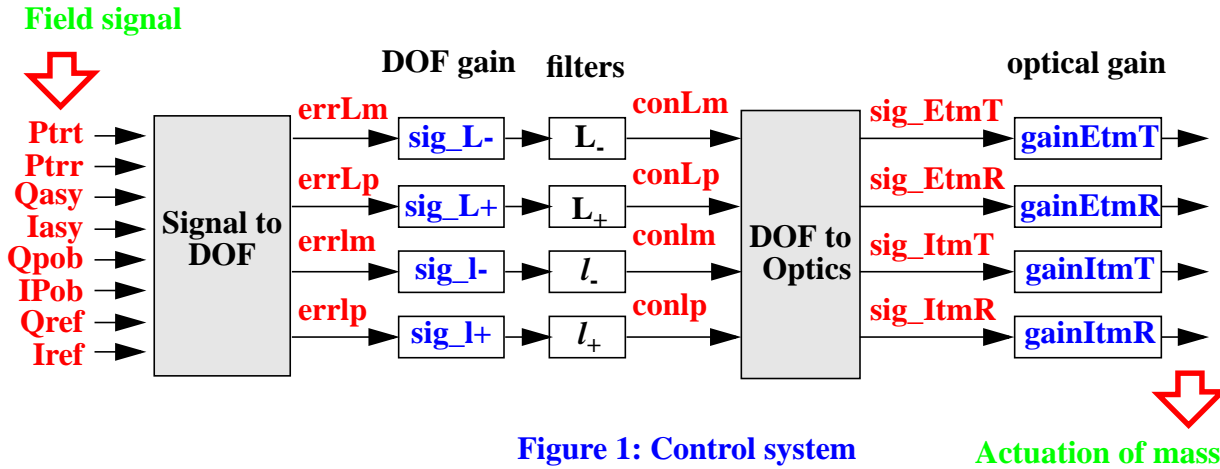
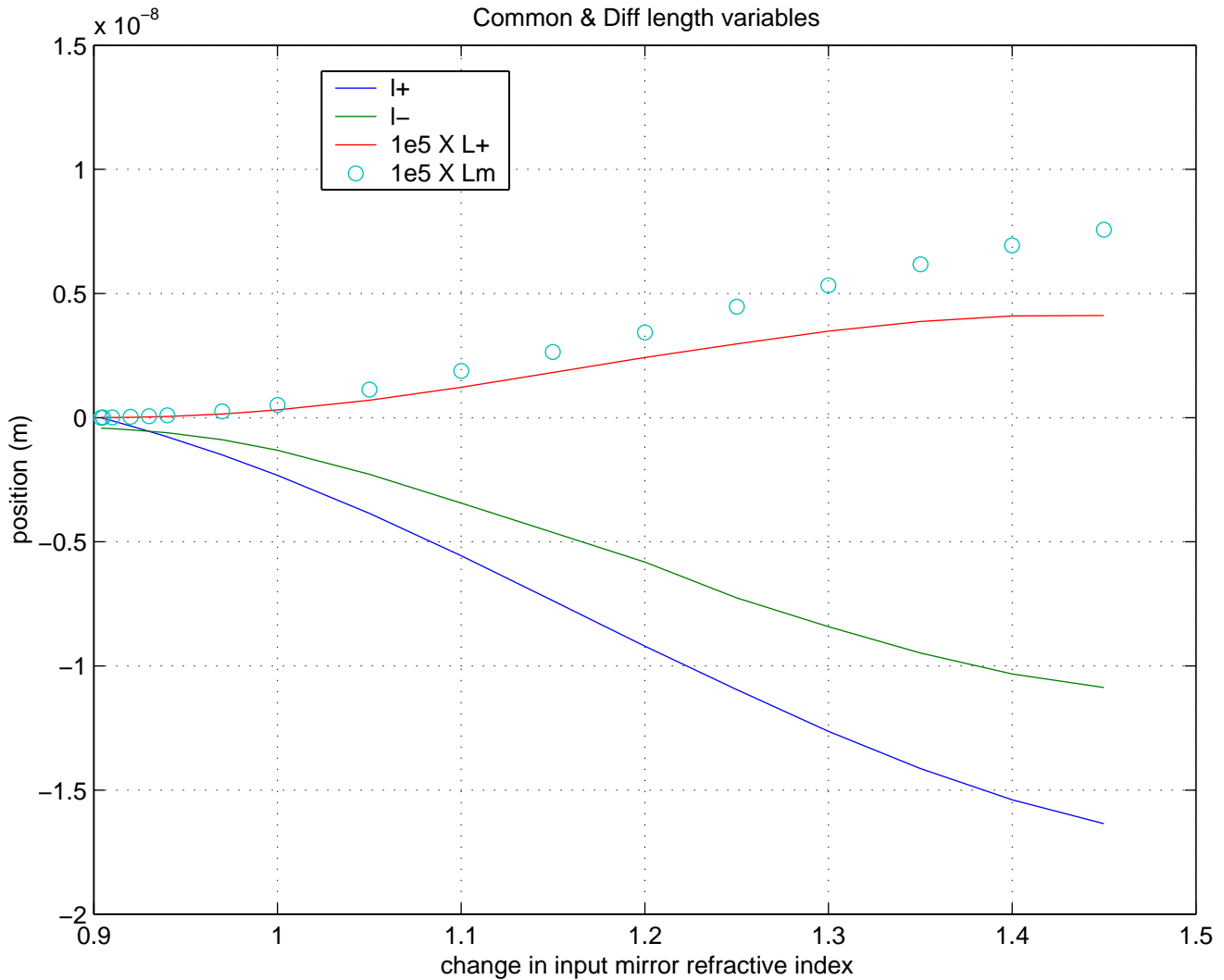


Figure 1: Control system

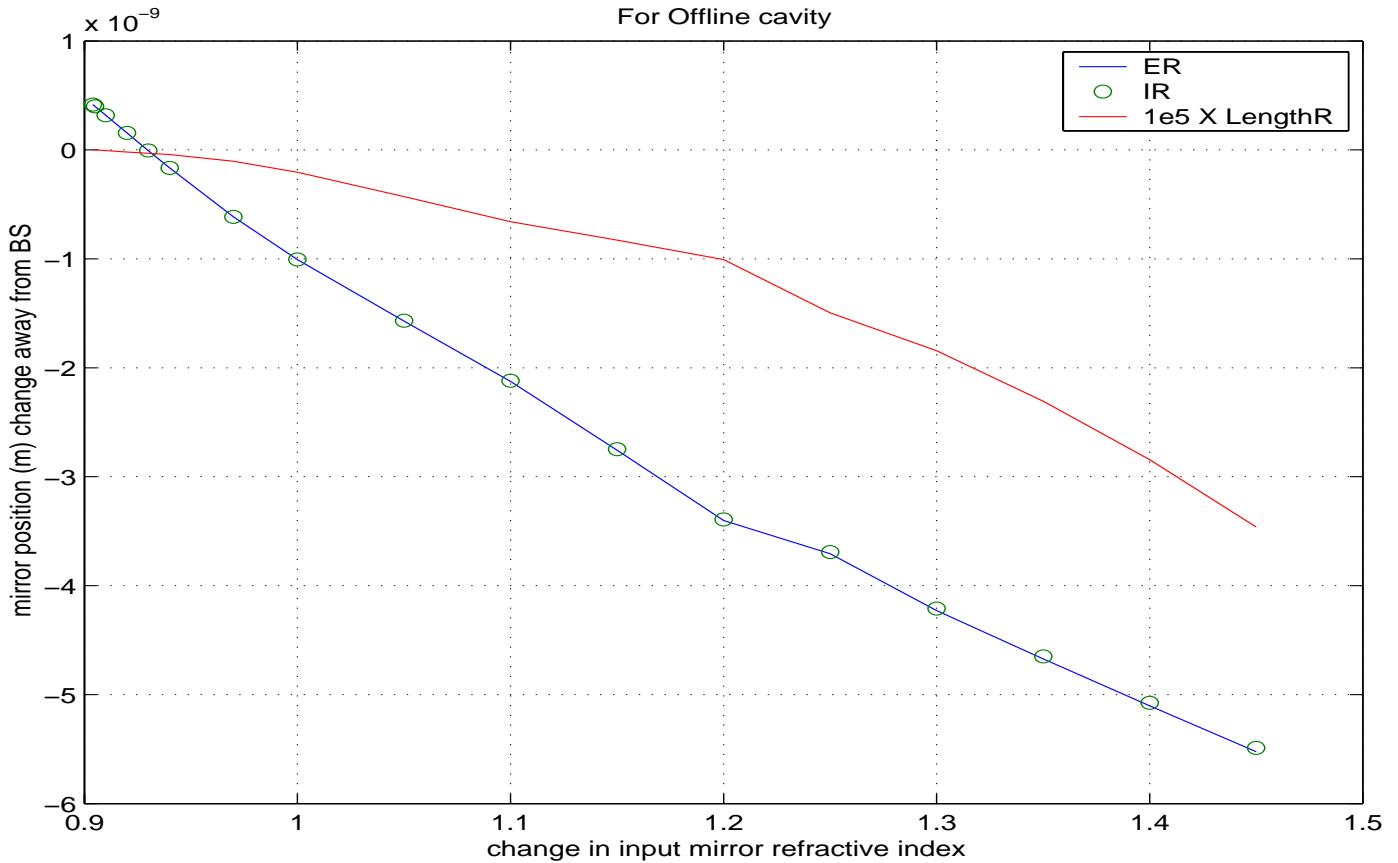
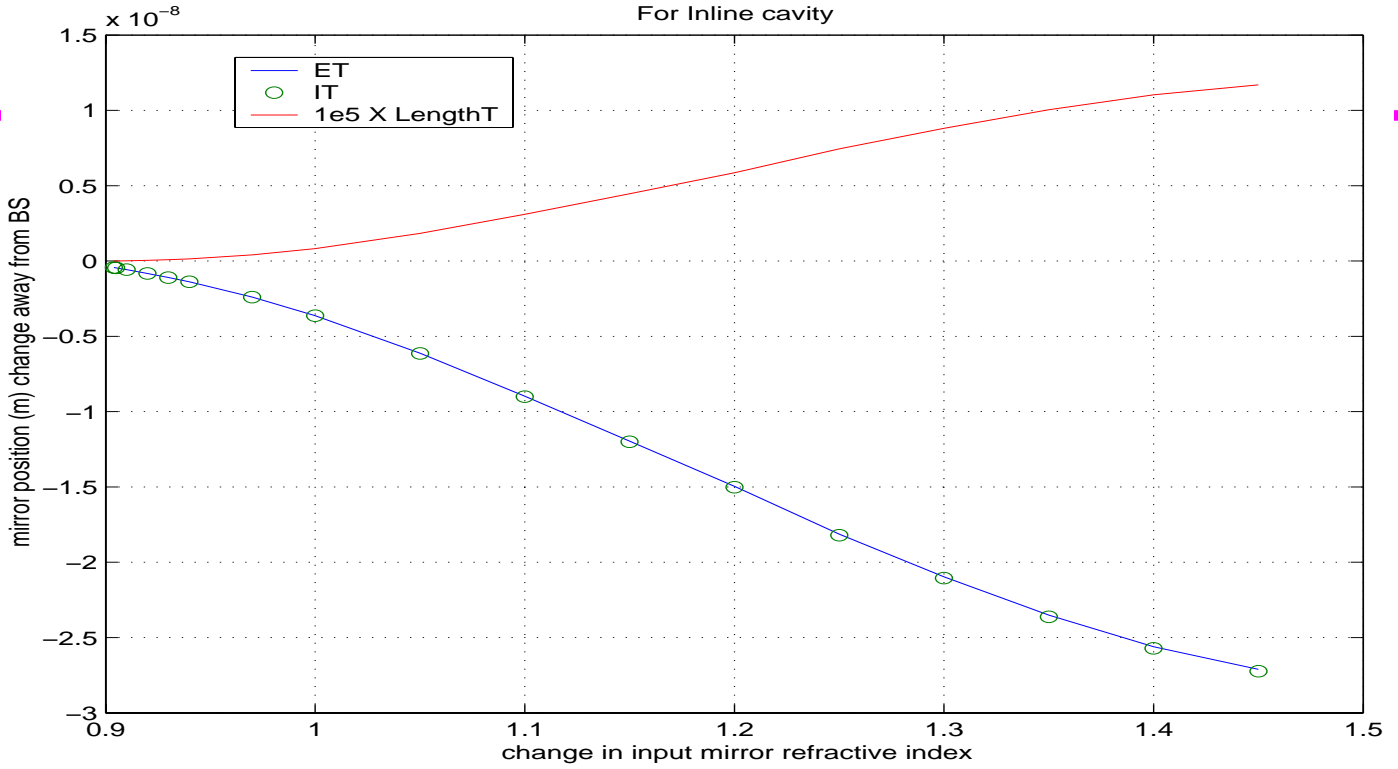
Actuation of mass

# How mirrors moved

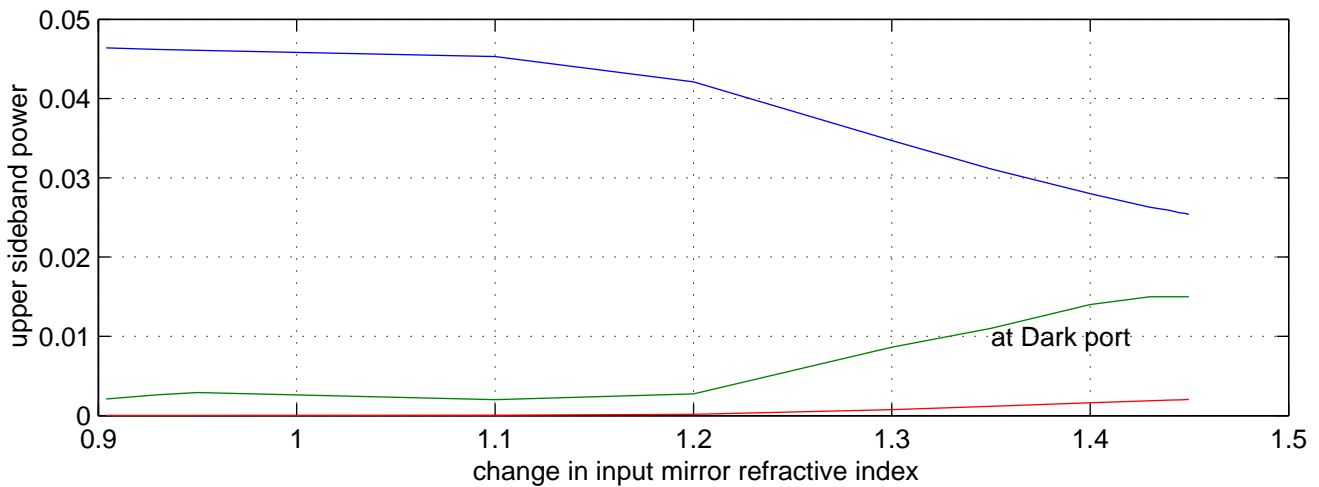
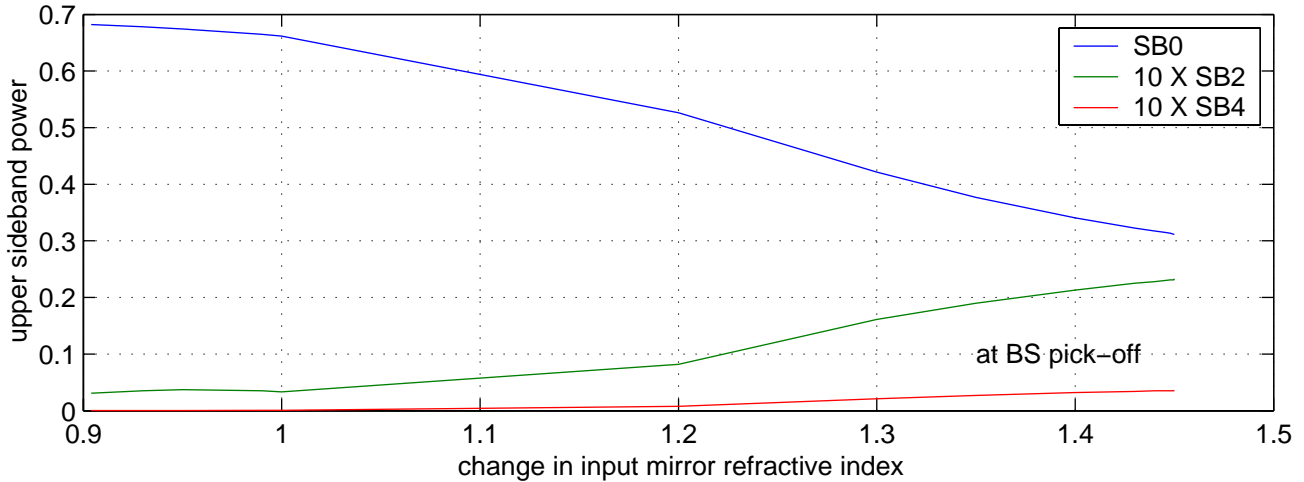


›› Very little change in arm cavity power (reduction attributable to generation of higher order power)

# How mirrors moved

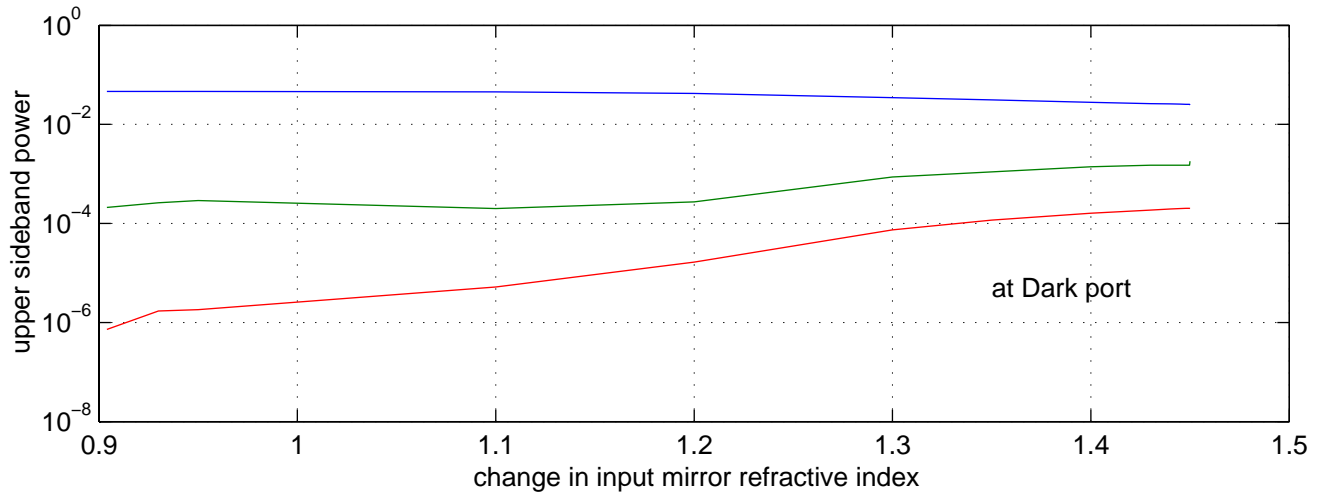
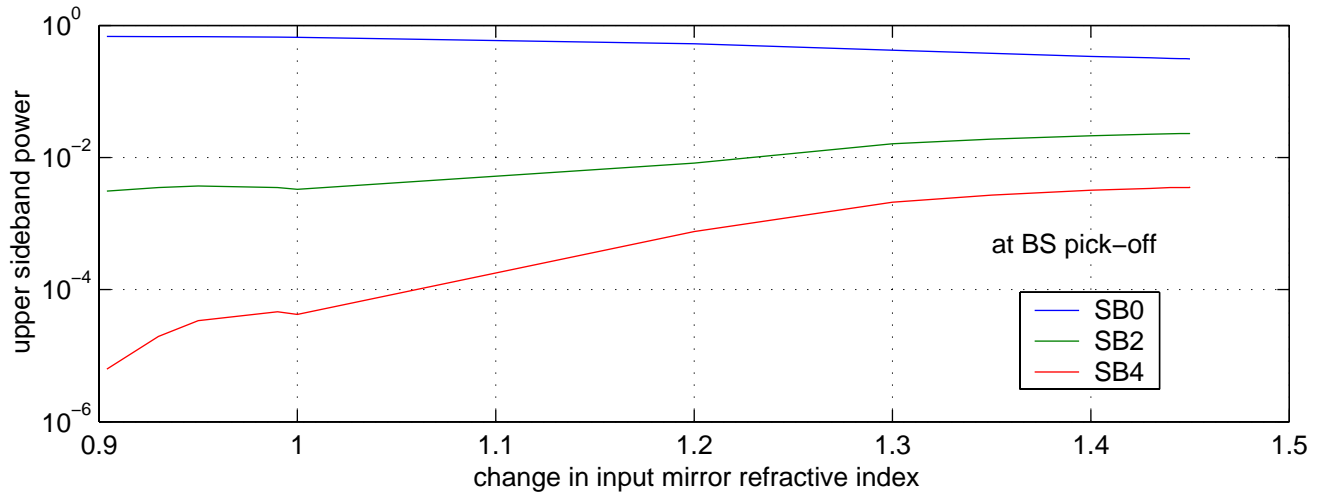


# How sideband power change as IFO gets hotter



›› reduction in SB power is mainly due to mirror displacement originated from mismatch

# How sideband power change as IFO gets hotter



# Further work

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- Closer look. Comparison with FFT runs
- Effect of beam-splitter curvature  
(W2K: -143Km, W4K: -336 Km, LA4K: -189Km )
- Effect of modal mismatch on SB mismatch
- Does 'mode-mismatch noise' exist and is that a concern ?