LIGO as it goes from cold to hot state
E2E simulation studies

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LSC meeting, LLO

Biplab Bhawal

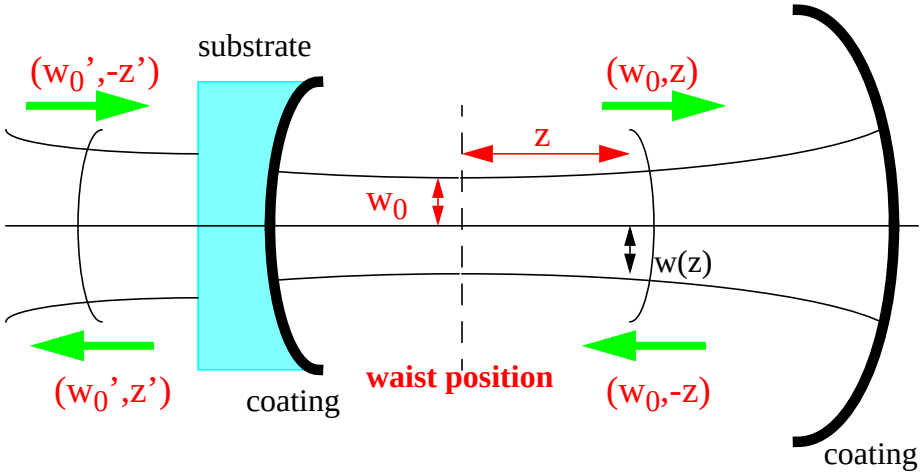
LIGO, Caltech

- Other contributors: Matt Evans, Hiro Yamamoto

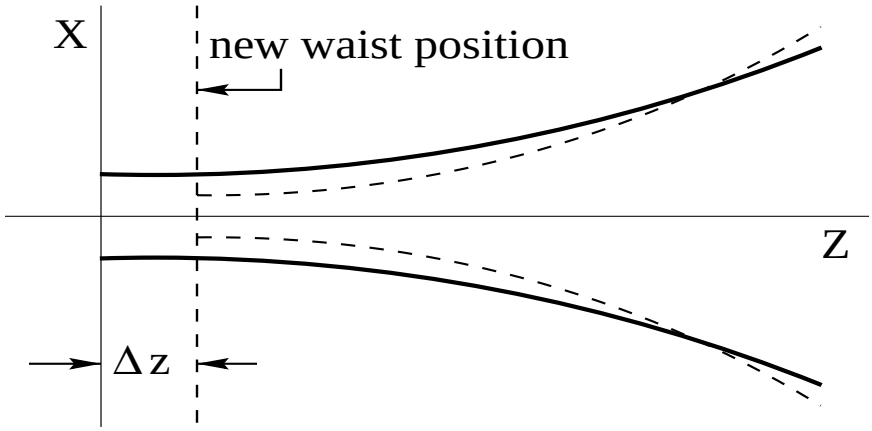
Final Aim

- 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

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

- Z0 (Rayleigh range) is ~3000 meter in LIGO arms

perturbation effects
(ref: Anderson,1984)

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

$$AU_0$$

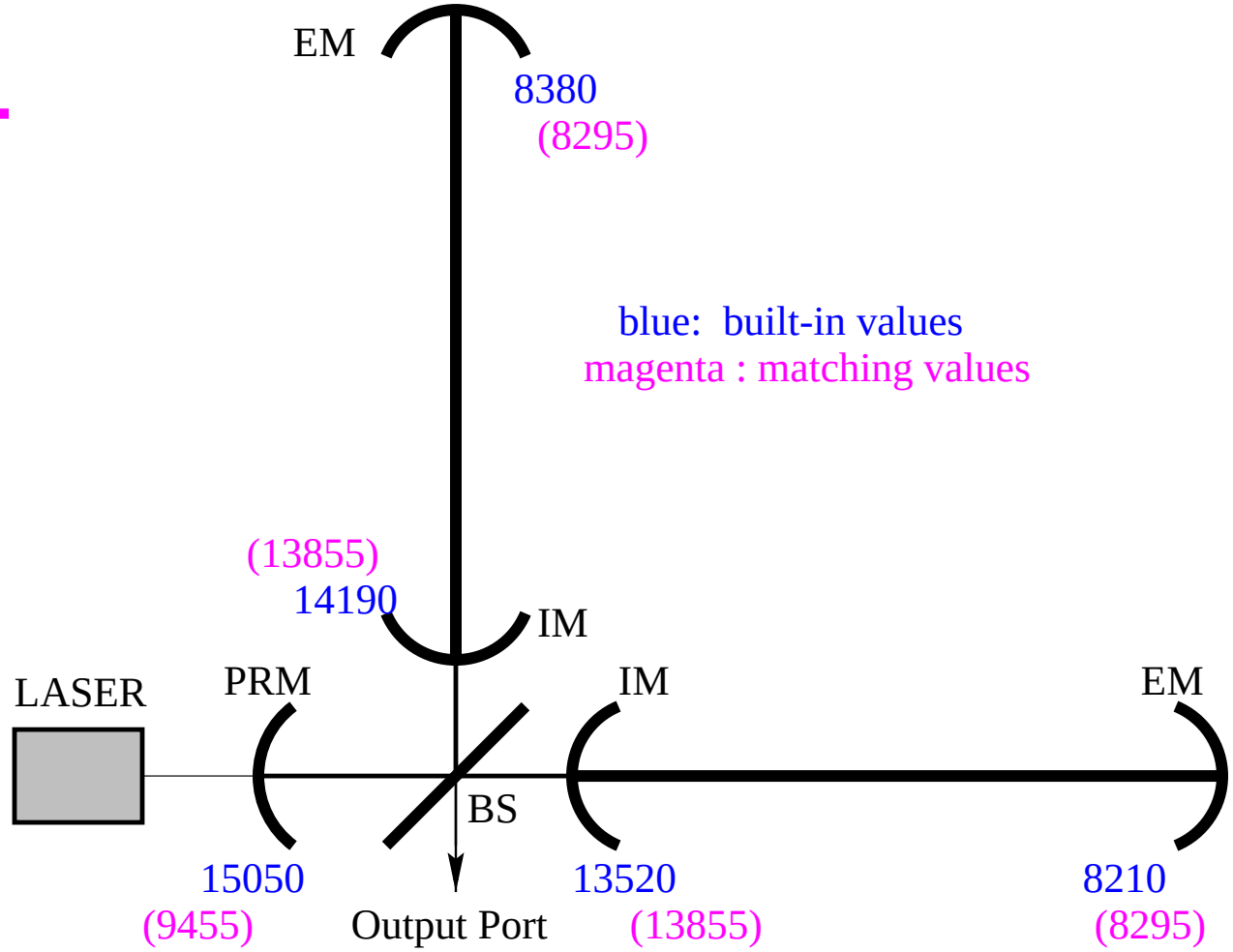
- Waist-position mismatch (b) :

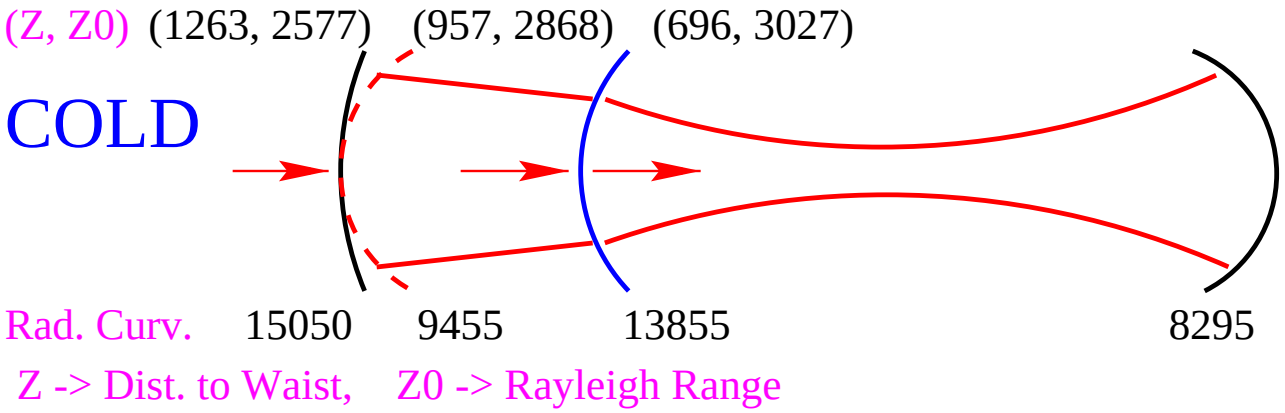
$$A\left[U_0 + j\frac{b}{2kw^2}\{U_0 + U_2\}\right]$$

- Waist-size mismatch (s) :

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

LIGO Interferometer

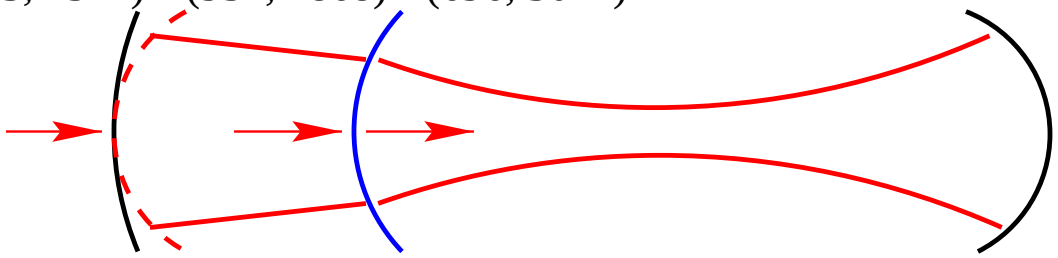




Han2k: Cold & Hot states

(Z, Z0) (1263, 2577) (957, 2868) (696, 3027)

COLD

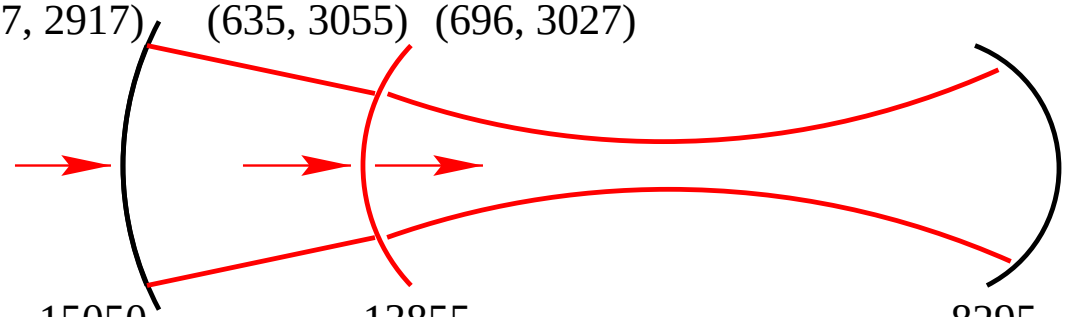


Rad. Curv. 15050 9455 13855 8295
Refr. Index 1.45 1.45 1.45

Z -> Dist. to Waist, Z0 -> Rayleigh Range

(Z, Z0) (897, 2917) (635, 3055) (696, 3027)

HOT



Rad. Curv. 15050 13855 8295
Refr. Index 1.45 0.904 1.45

Procedure

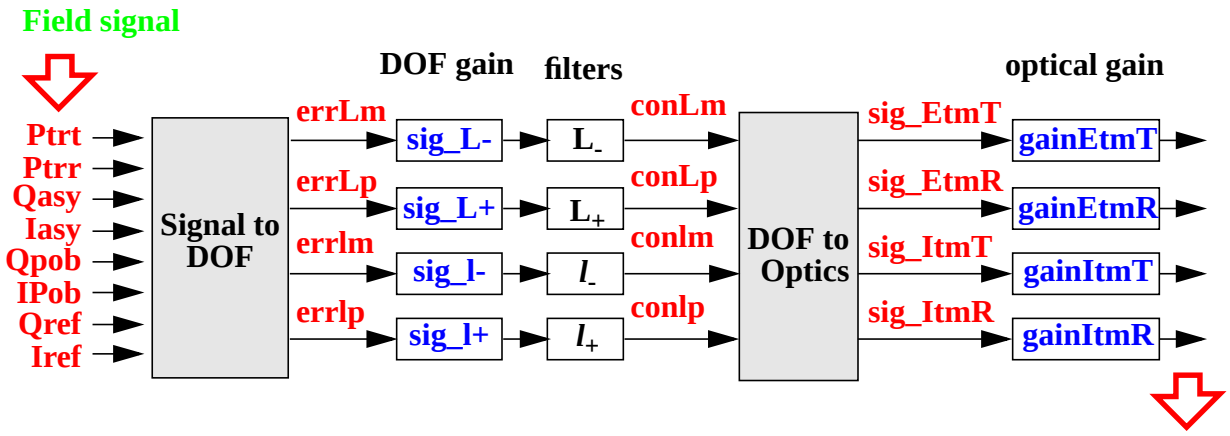
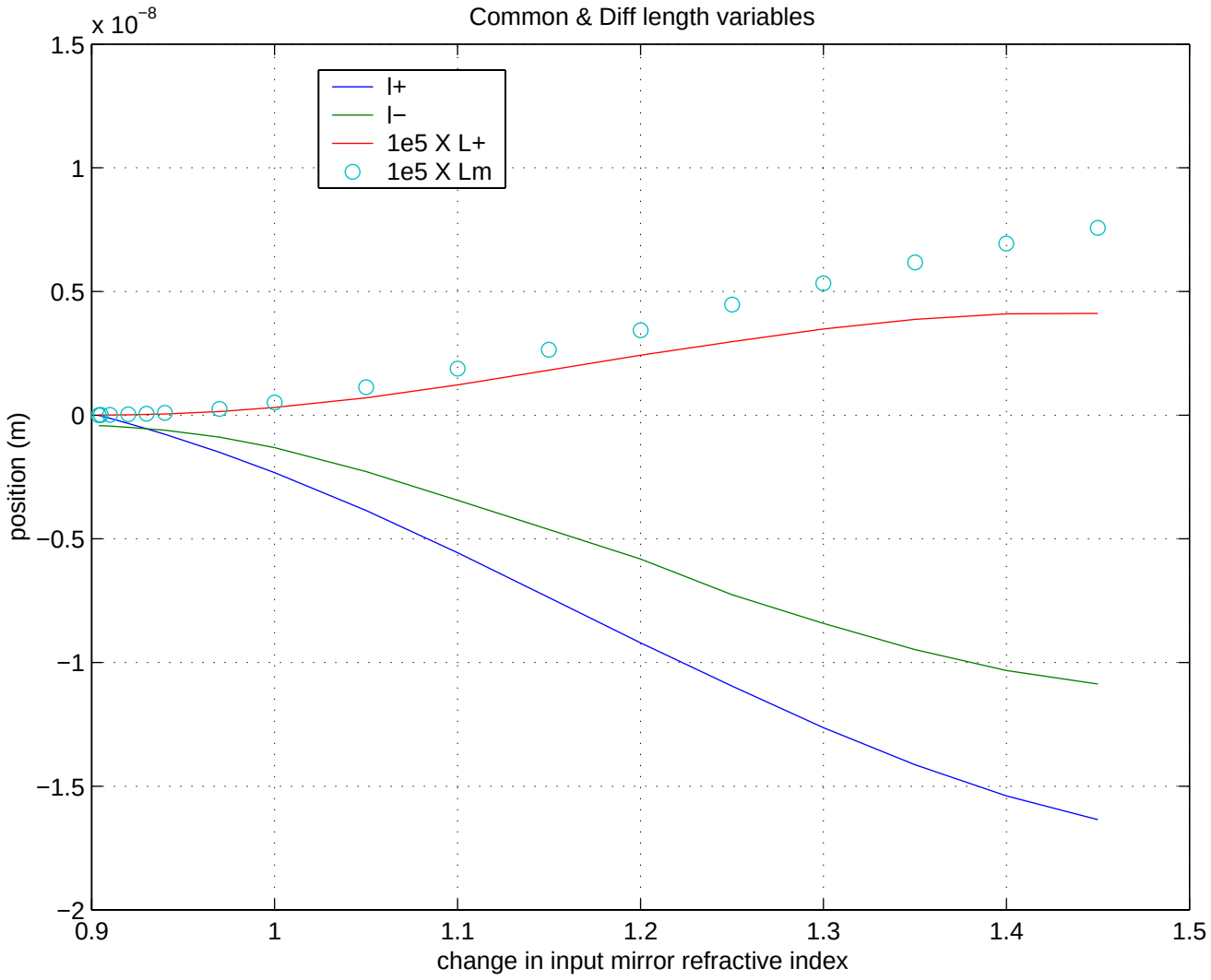


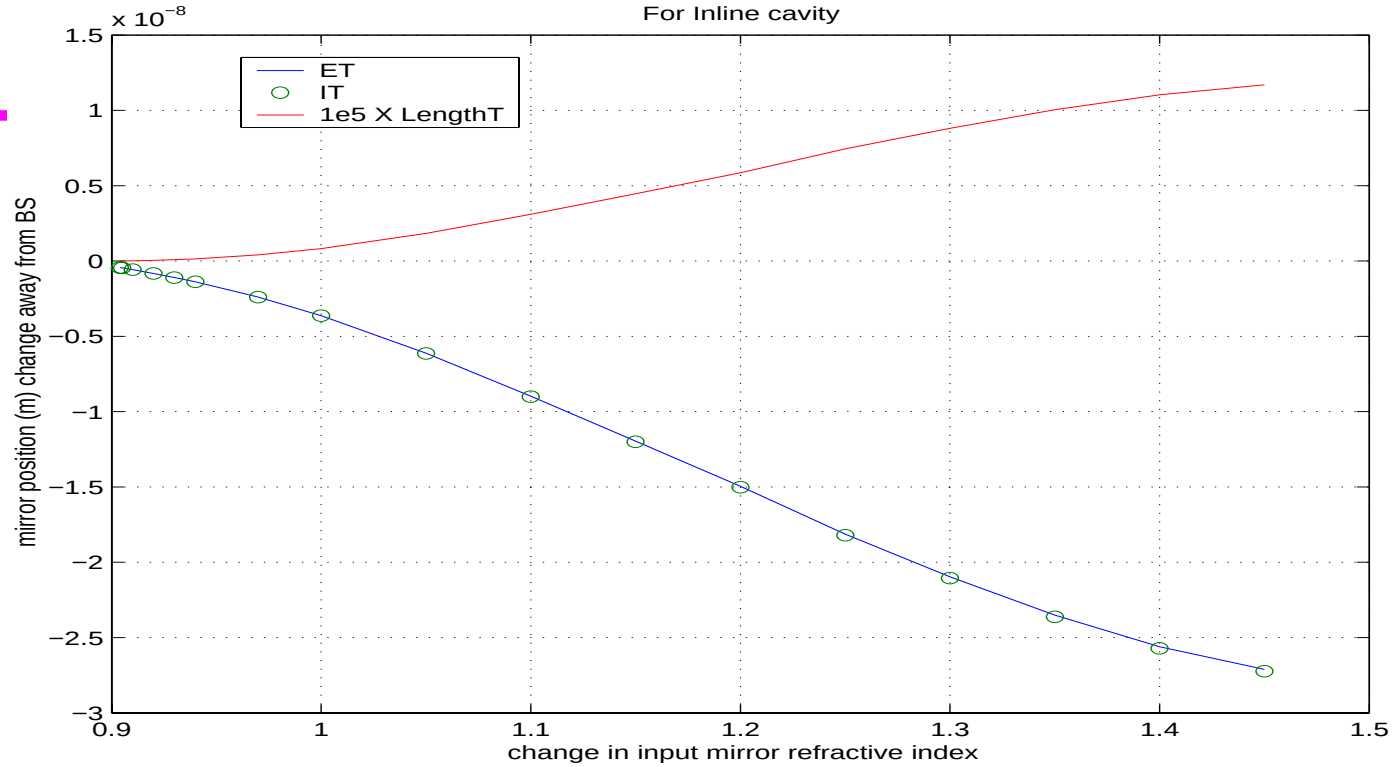
Figure 1: Control system

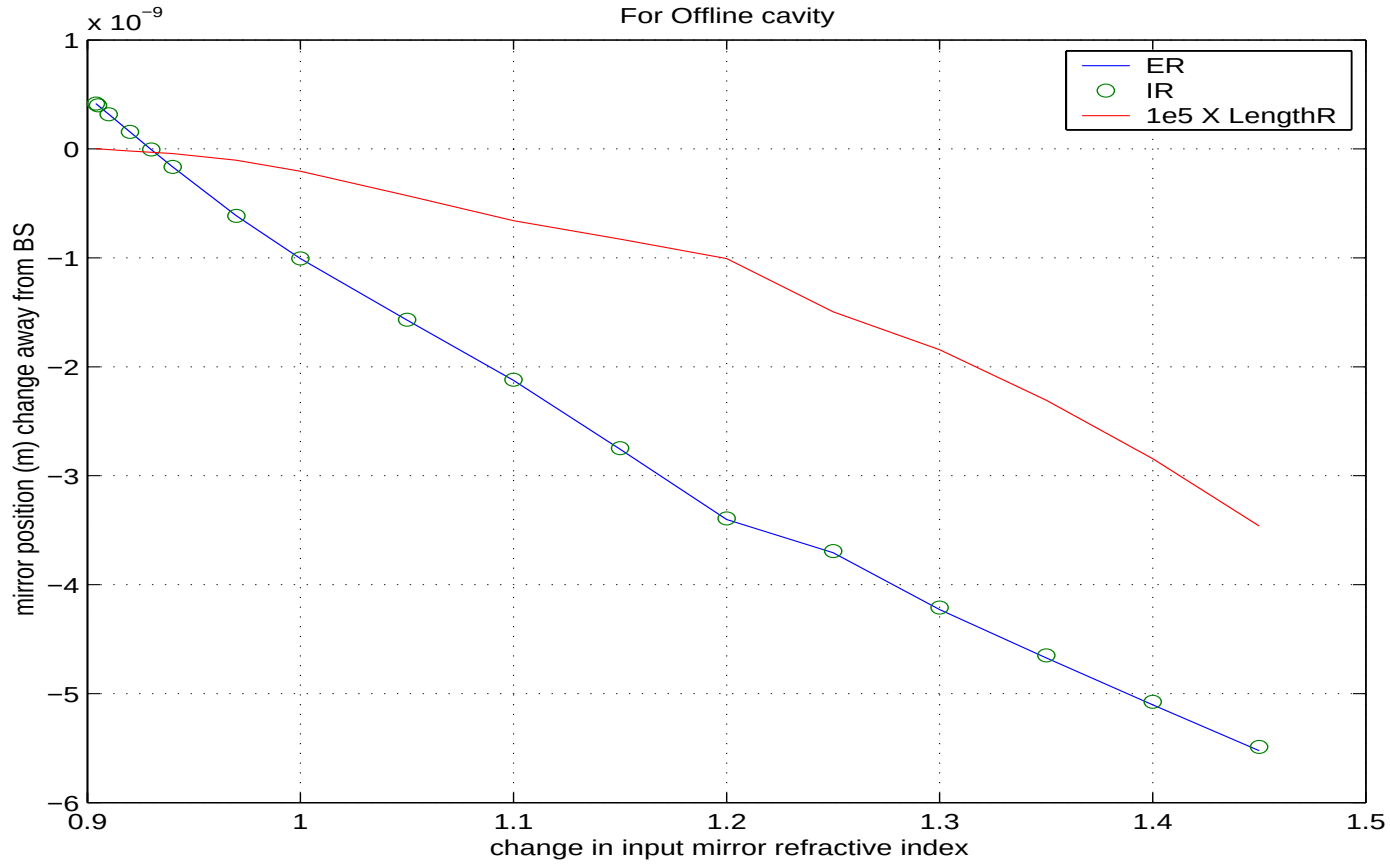
How mirrors moved



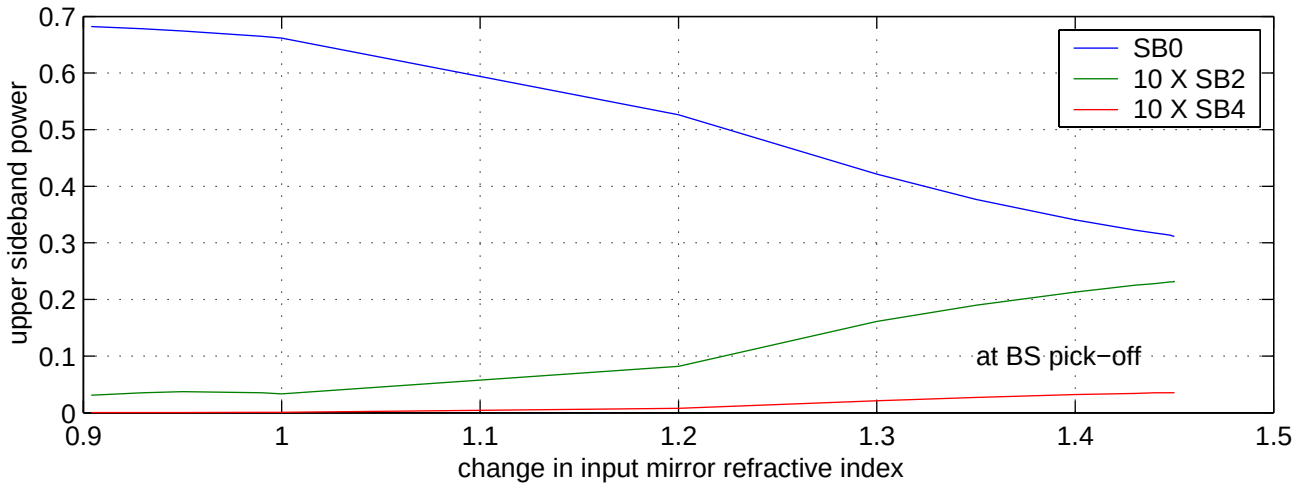
- Very little change in arm cavity power (reduction attributable to generation of higher order power)

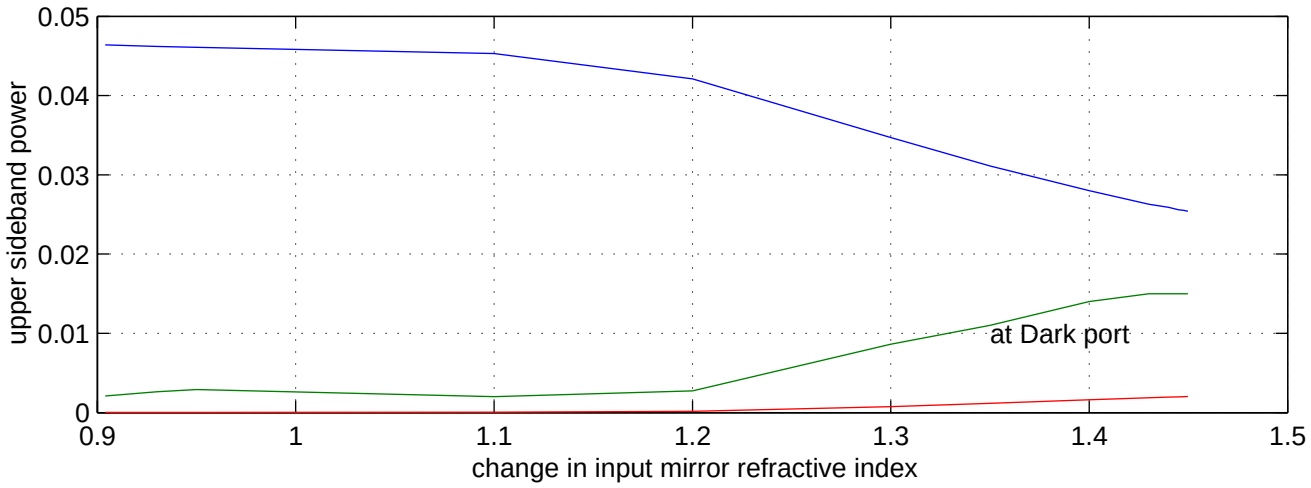
How mirrors moved





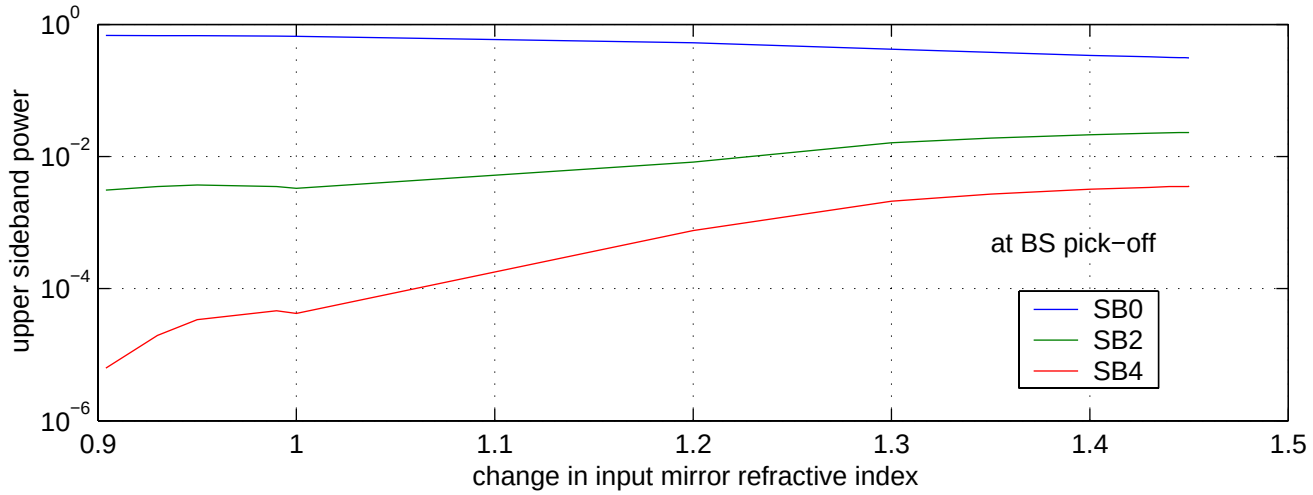
How sideband power change
as IFO gets hotter

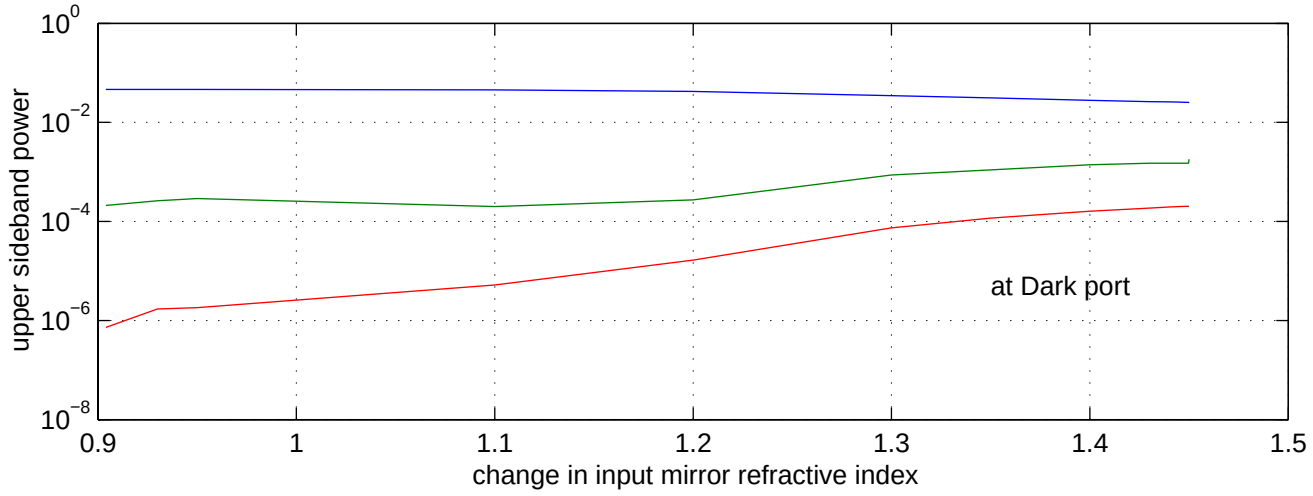




- reduction in SB power is mainly due to mirror displacement originated from mismatch

How sideband power change
as IFO gets hotter





Further work

- 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 ?