In-situ measurements of thermally-induced input test mass curvature changes

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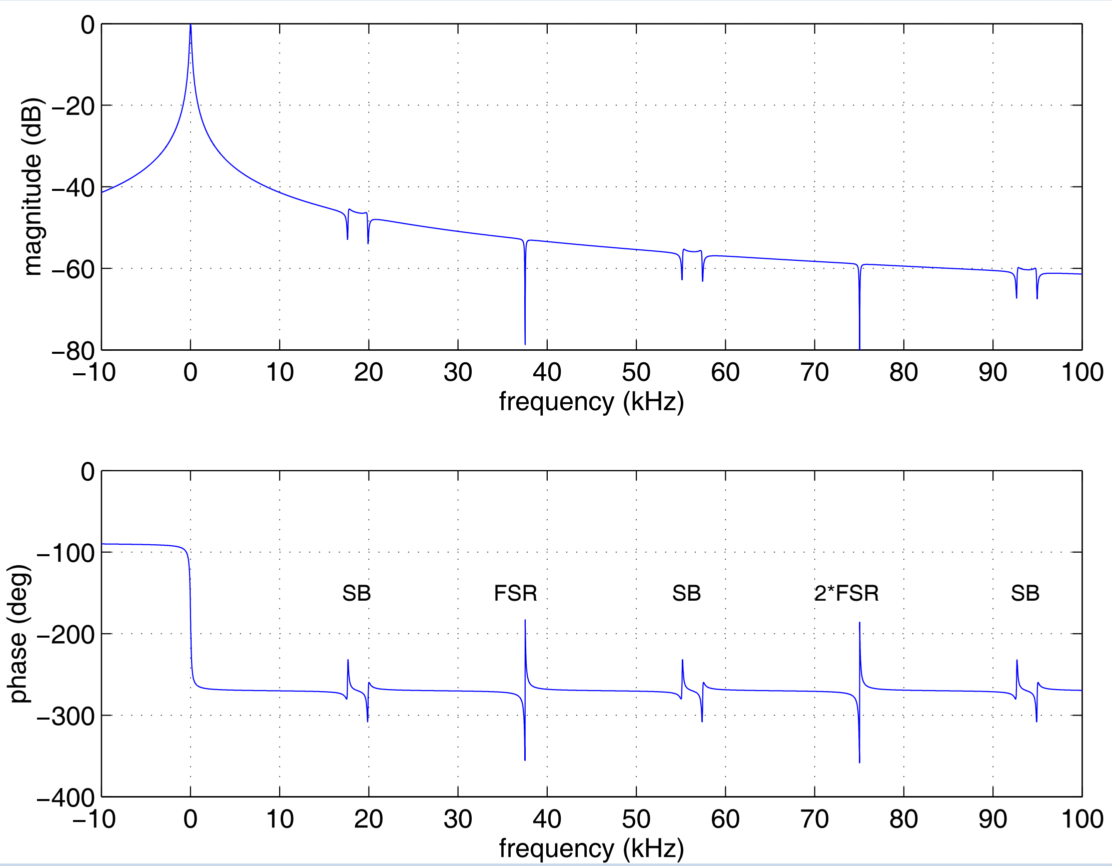
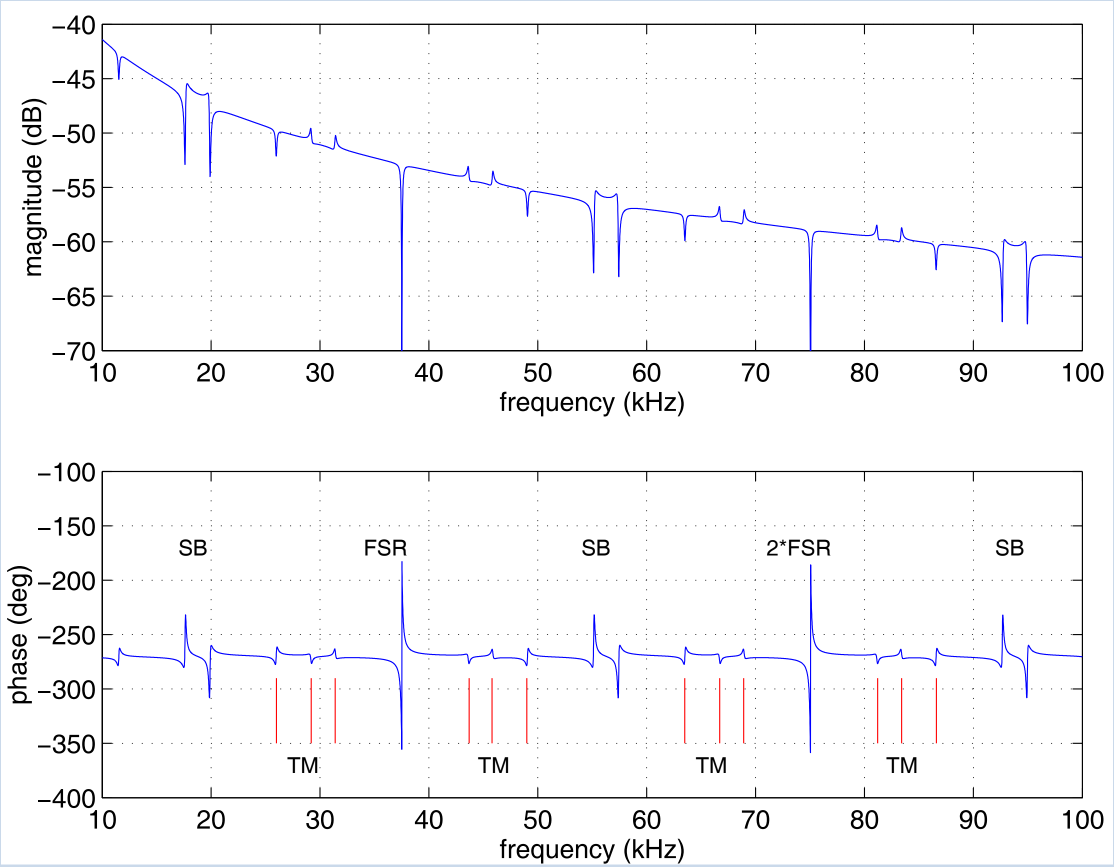
Measurement Technique

- Dynamic resonance of light in Fabry-Perot cavities
- Laser frequency to PDH signal transfer function, **$H_{\omega}(s)$**, has cusps at multiples of FSR and features at frequencies related to the modulation sidebands.



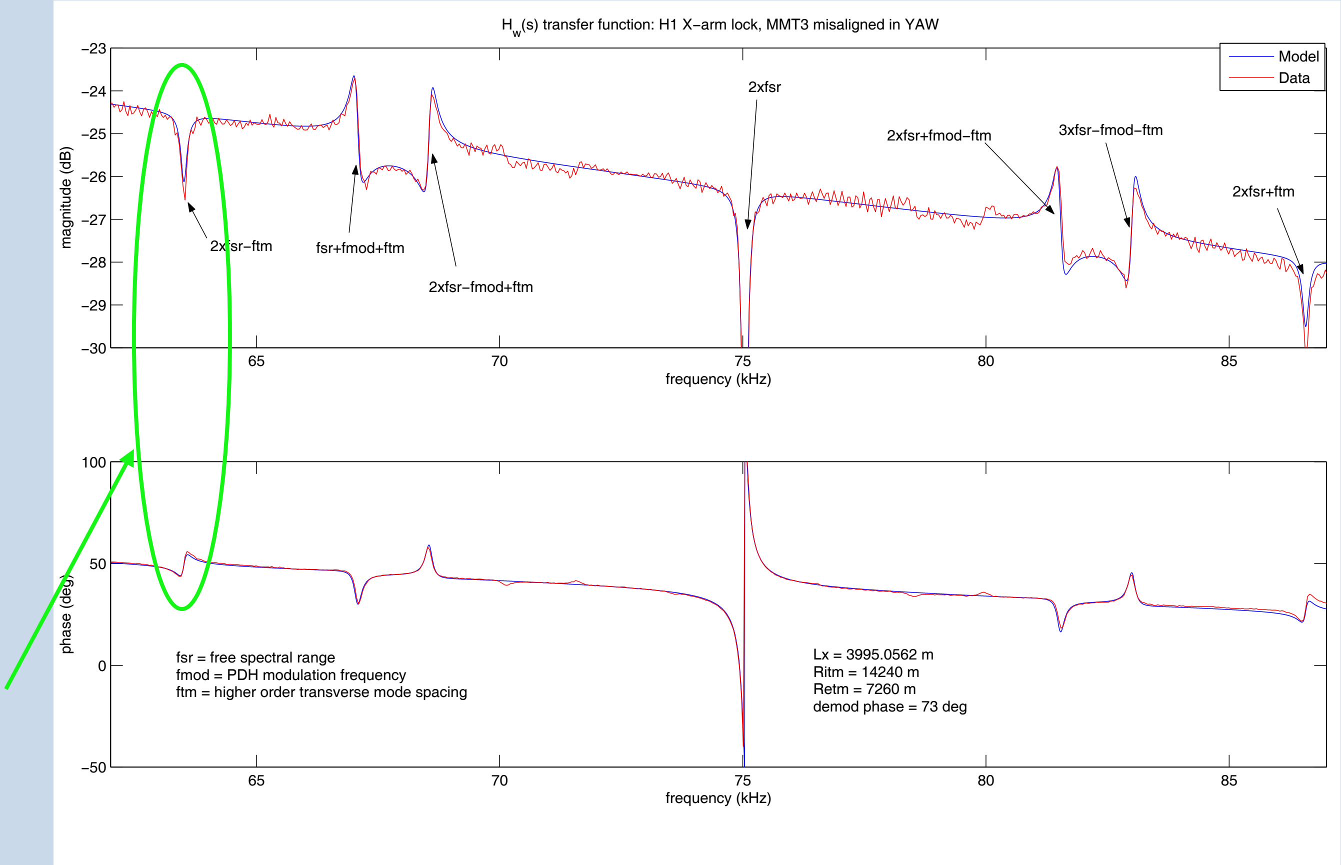
Misaligned cavity

- Features appear at frequencies related to higher-order transverse modes.
- Transverse mode spacing: $\mathbf{f_{tm} = f_{01} - f_{00} = (f_{fsr}/\pi)\ acos\ (g_1 g_2)^{1/2}}$
- $\mathbf{g_{1,2} = 1 - L/R_{1,2}}$
- Infer mirror curvatures from transverse mode spacing.
- This technique proposed by F. Bondu, Aug. 2002.



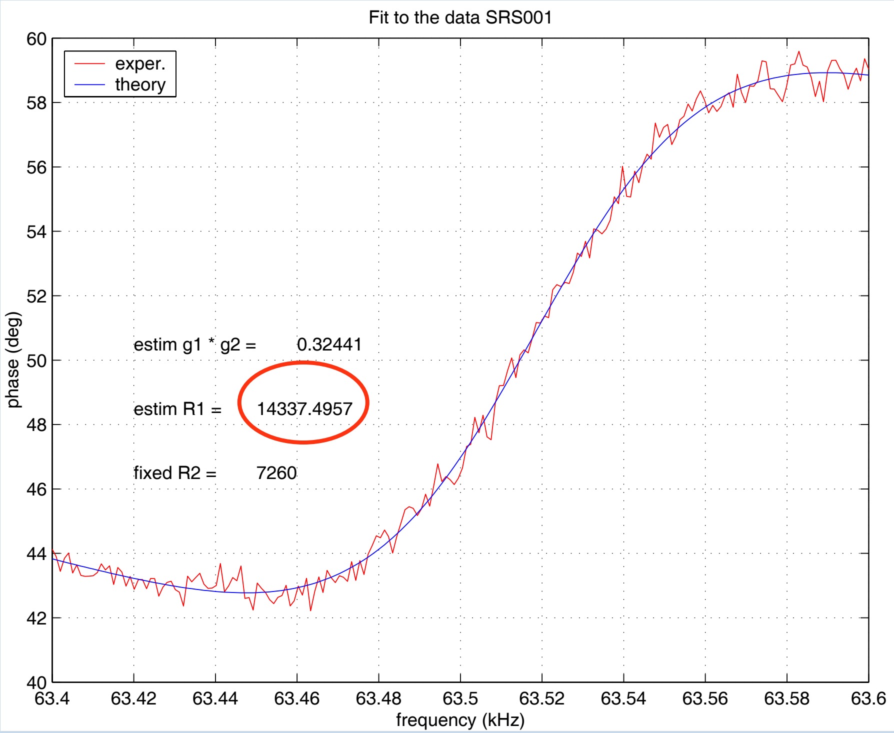
H1 data – Sept. 23, 2003

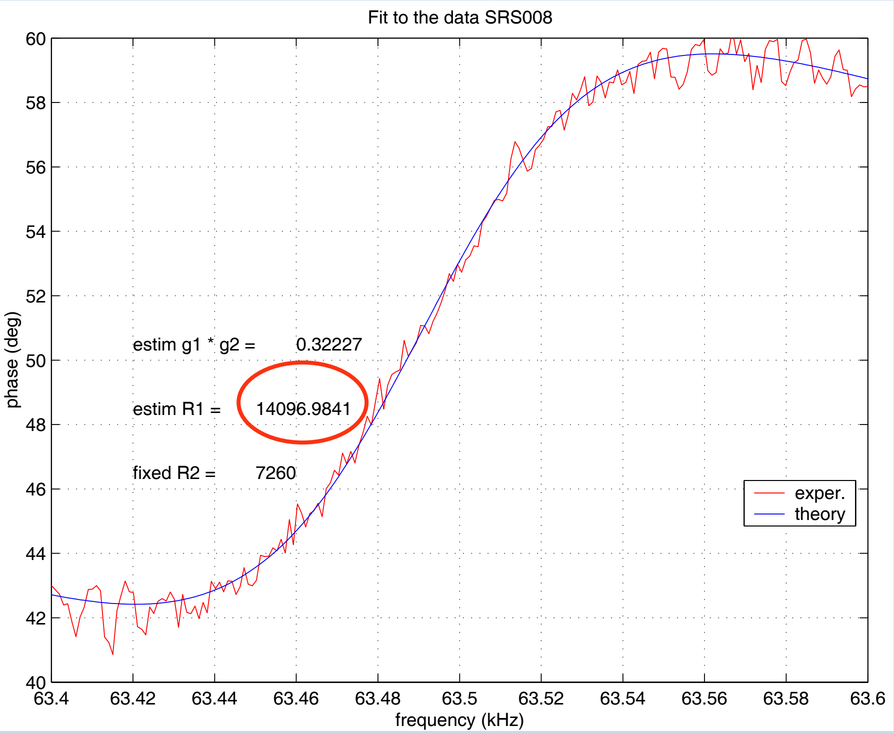
- Lock a single arm
- Mis-align MMT3 in yaw
- Drive VCO test input
- Measure TF to ASPD Q_{mon} or I_{mon} signal
- Focus on phase of feature near 63 kHz (arbitrary choice)



Data and (lsqcurve) fits.

ITMx annulus heating → decrease in ROC (increase in curvature)

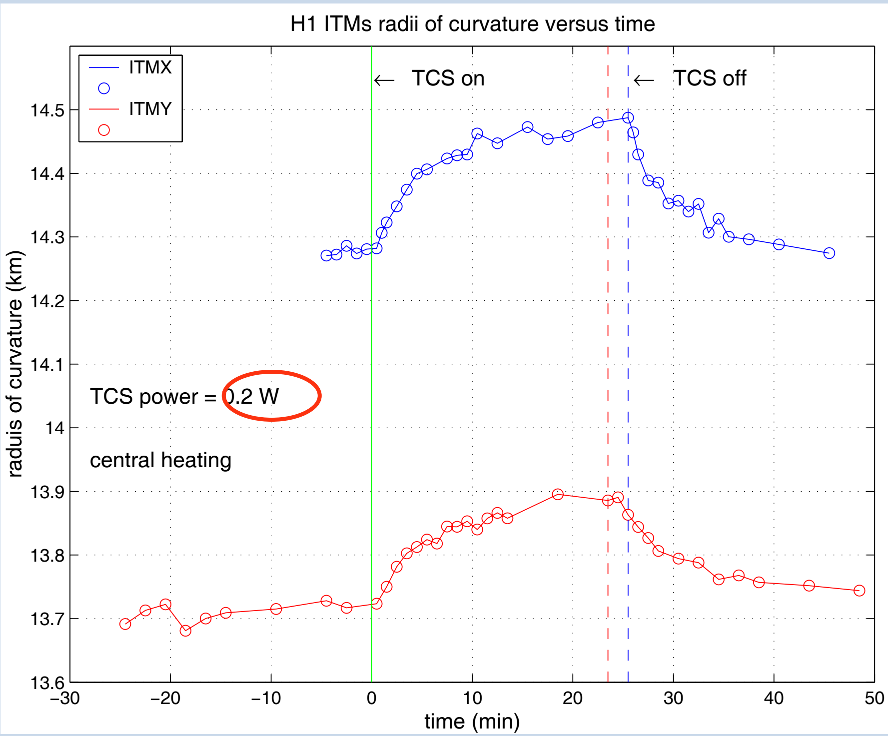




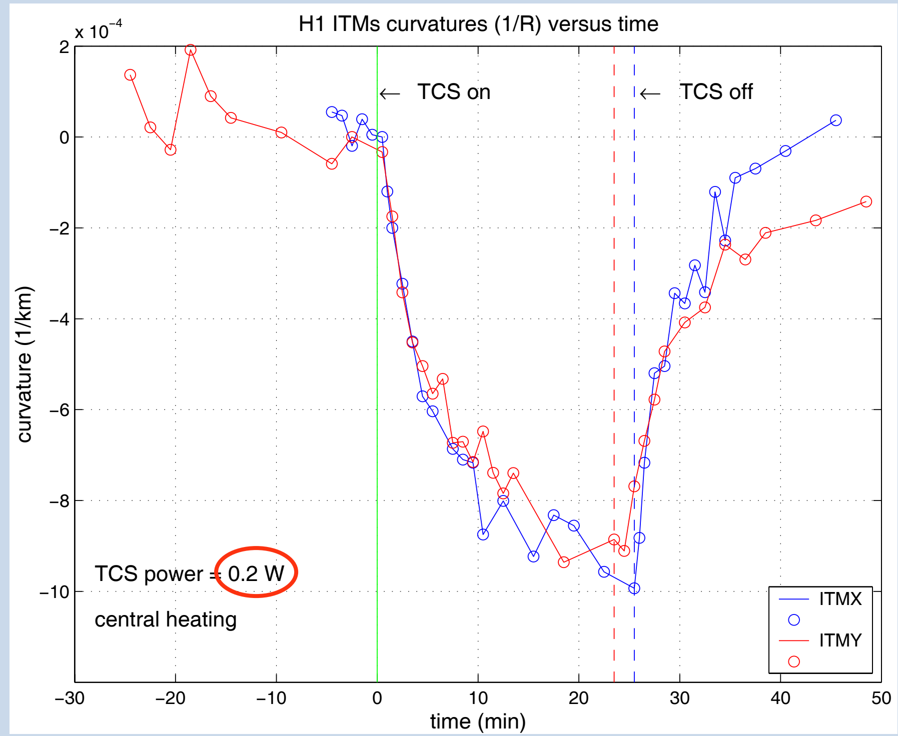
Assume metrology values: R_{ETMx} = 7260 m; R_{ETMy} = 7320 m
Metrology value for ITMx = 14240 m; ITMy = 13600 m

H1 – 37 mW central TCS heating

Start with cold optics – ifo. unlocked for several hours.

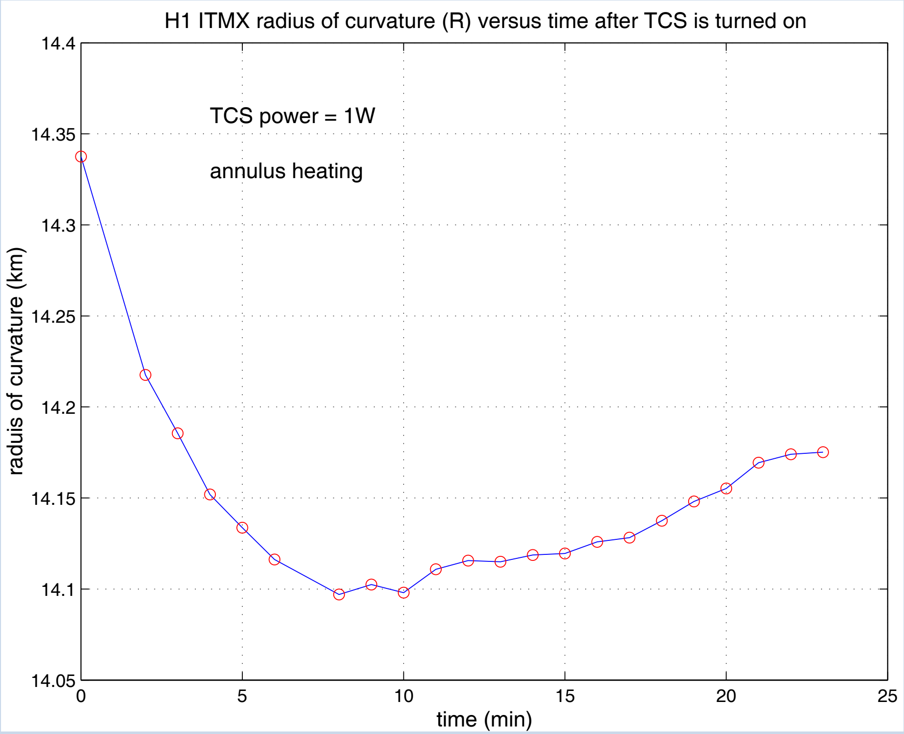


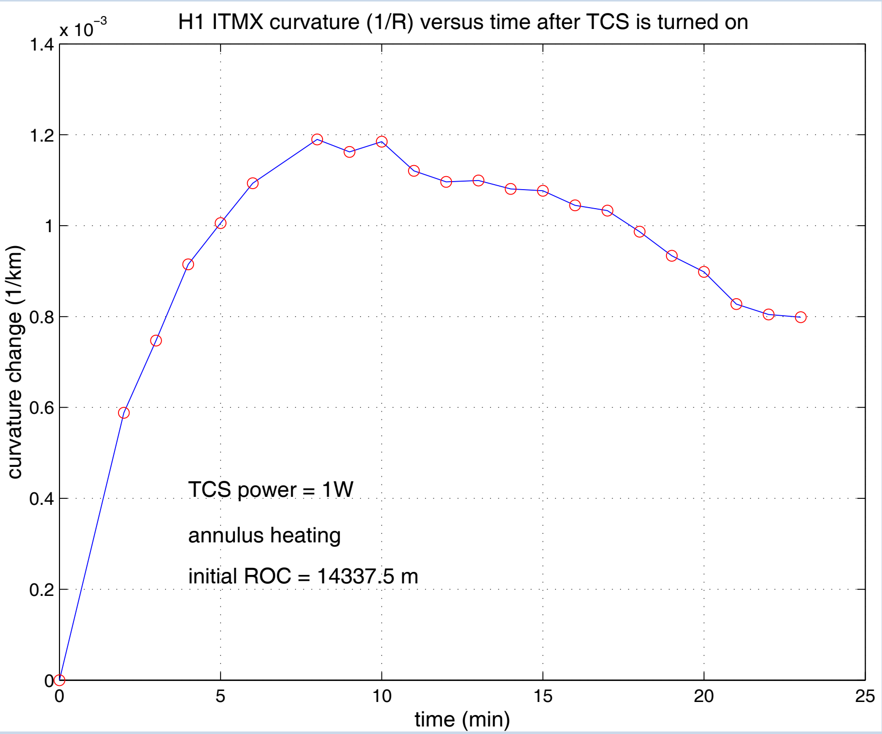
Radius of curvature



Curvature

ITMx – 1.0 W annulus heating

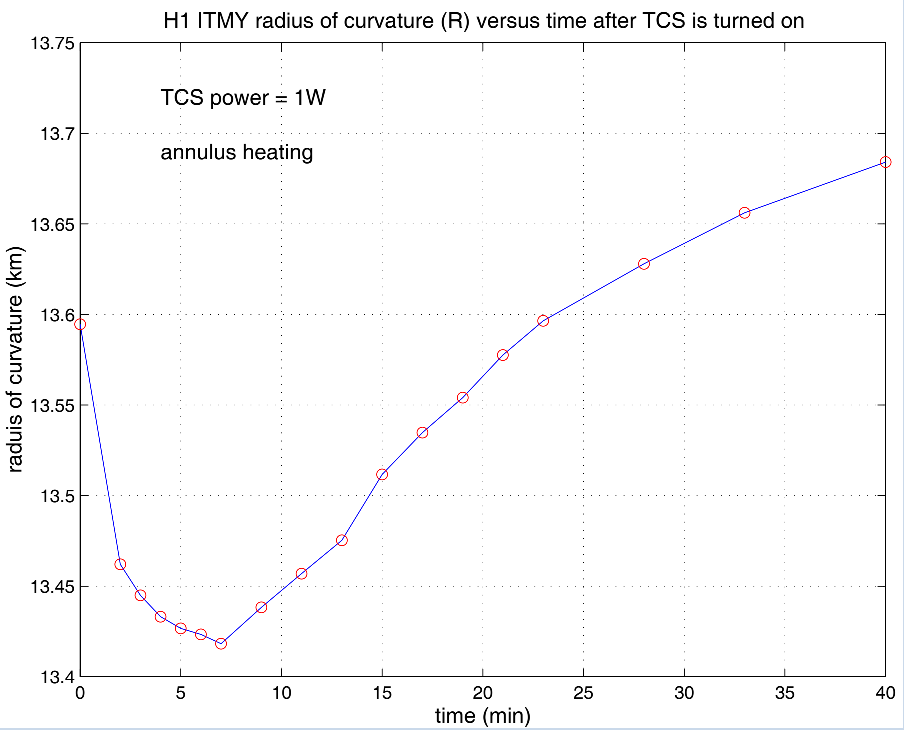


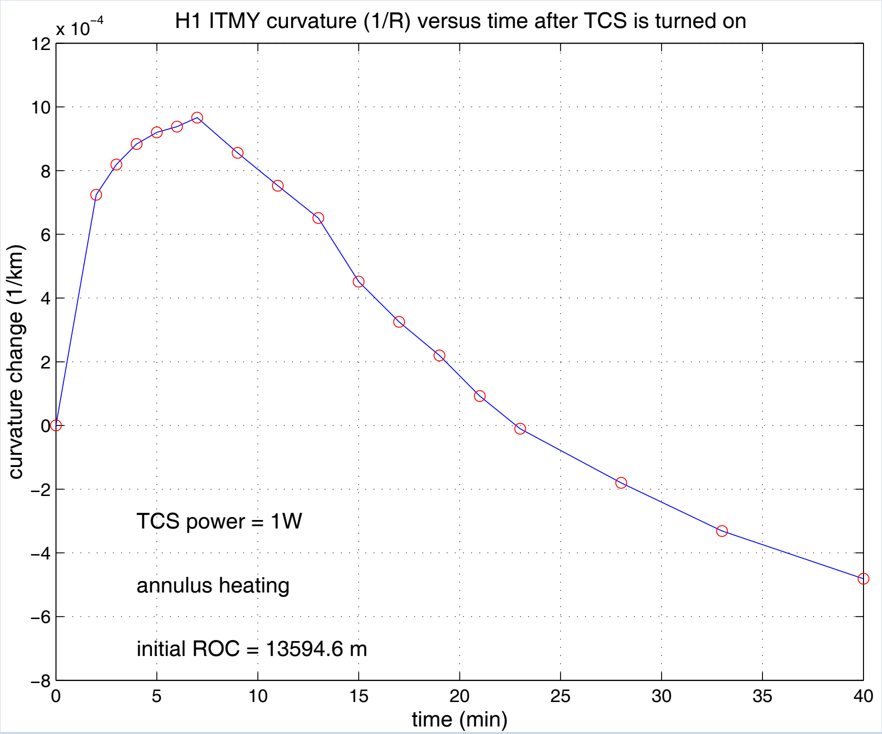


Radius of curvature

Curvature

ITMy – 1.0 W annulus heating





Radius of curvature Curvature

Measured just after ifo. was in high power state with central TCS heating on ITMy

Next steps

- Measure heating induced by 1064 nm beam. Look for differences between ITMx and ITMy.
  - » Lock full interferometer without TCS at highest power level possible.
  - » Break lock, lock single arm, and measure $H_{\omega}(s)$ vs. time.
- Separate bulk from surface absorption in conjunction with other measurements – Joe B's POx and POy beam diameter measurements, etc.
- Compare results with thermal models – D. Ottaway, P. Willems, B. Kells, et al.
- Repeat ITMy annulus heating experiment.
- Optimize ITMx annulus heating to extend TCS range.