Thermal actuator update

Continued testing with 2” CFM

SAMS meeting (2019/06/20)

LIGO-E1900190

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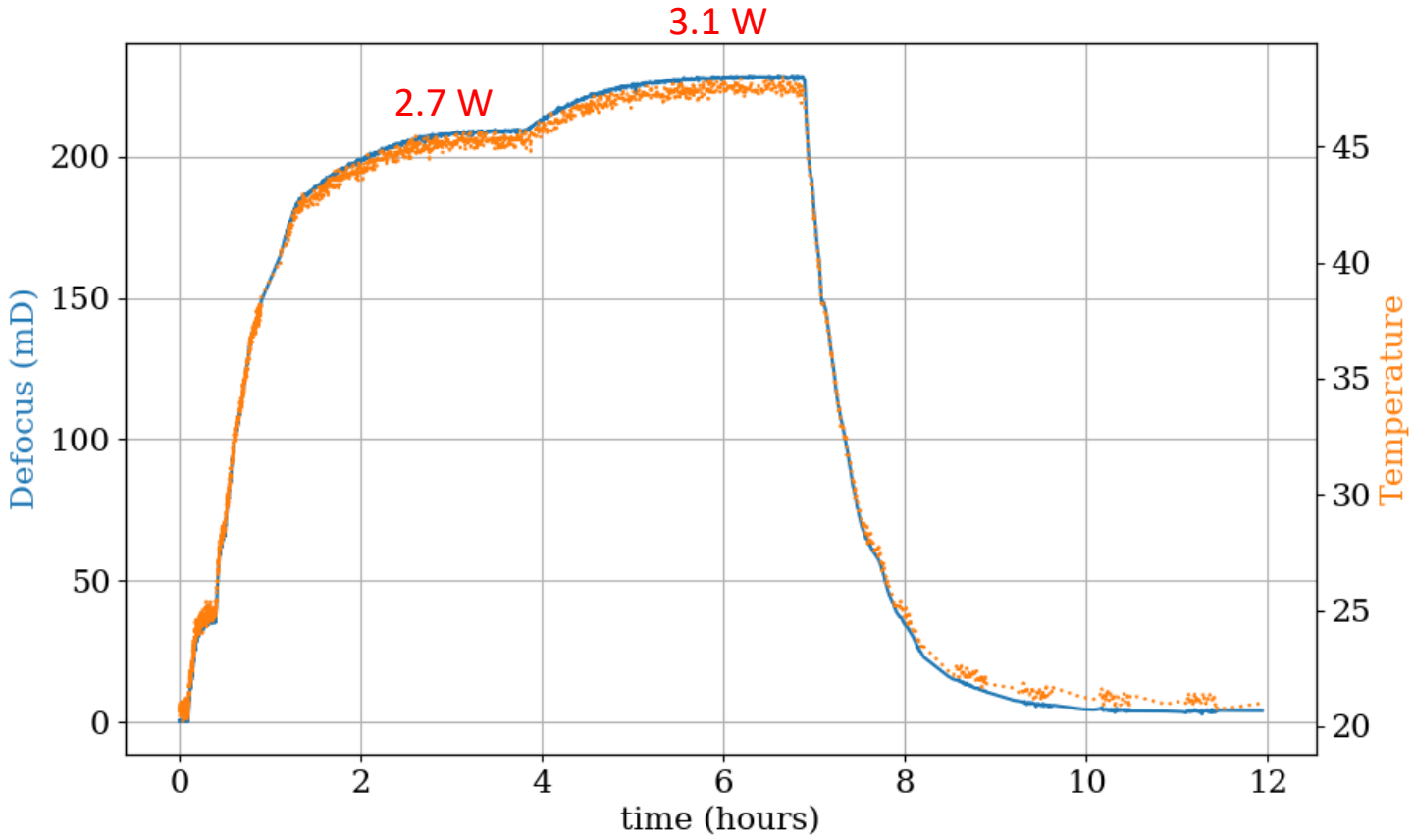
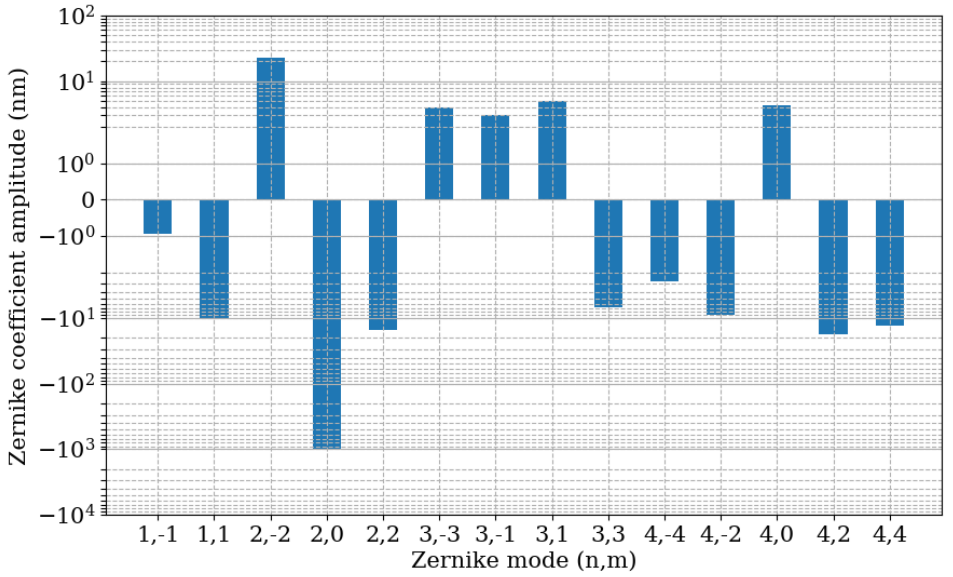
1. 2” CFM : More than 200 mD at ΔT=27.5 K

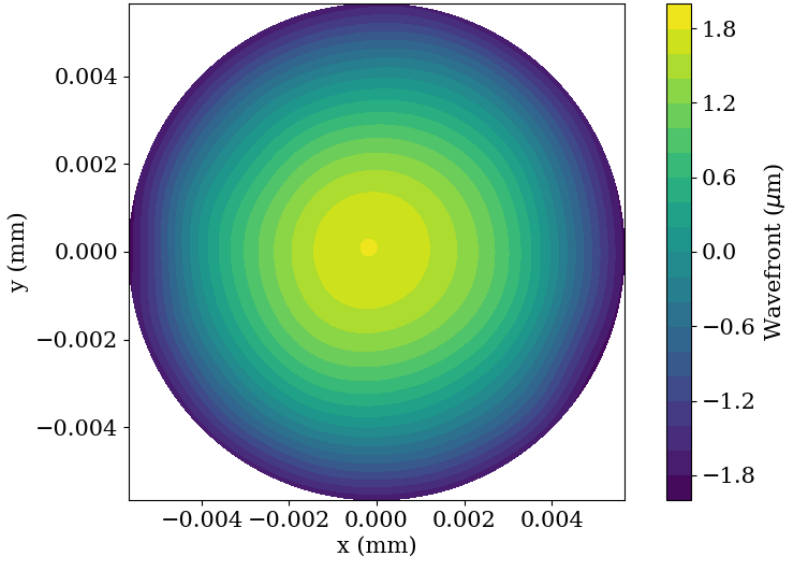
- 2” compression fit mirror (CFM) – flat-flat mirror, 6 mm thickness, 6mm-thick compression ring
- 228 mD at 3.1 W electrical input (voltage limited by power supply (max 30V DC)
- ΔT = 27.5 K
- Relatively long (1/e) thermal time constant : c.a. 0.5 hour
- Strong correlation with temperature, actuation rate c.a. 8.3 mD/K, slightly higher than anticipated form FEA (7 mD/K)
- CFM continues testing through various cycle
- Temperature PID lock will be implemented next week



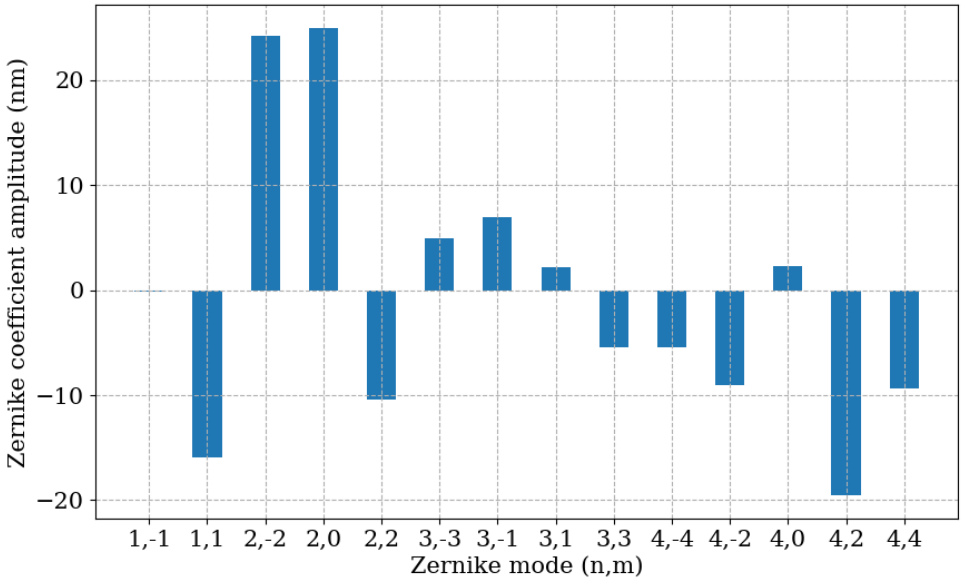
1. 2” CFM: closer look at wavefront actuation map

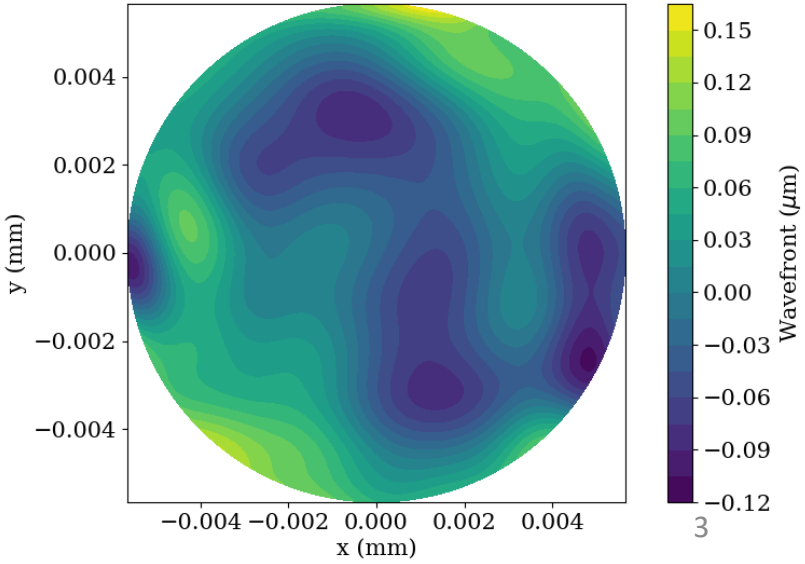
1. Full wavefront map at maximum deformation (228 mD) - dominated by defocus term (2,0 Zernike term)



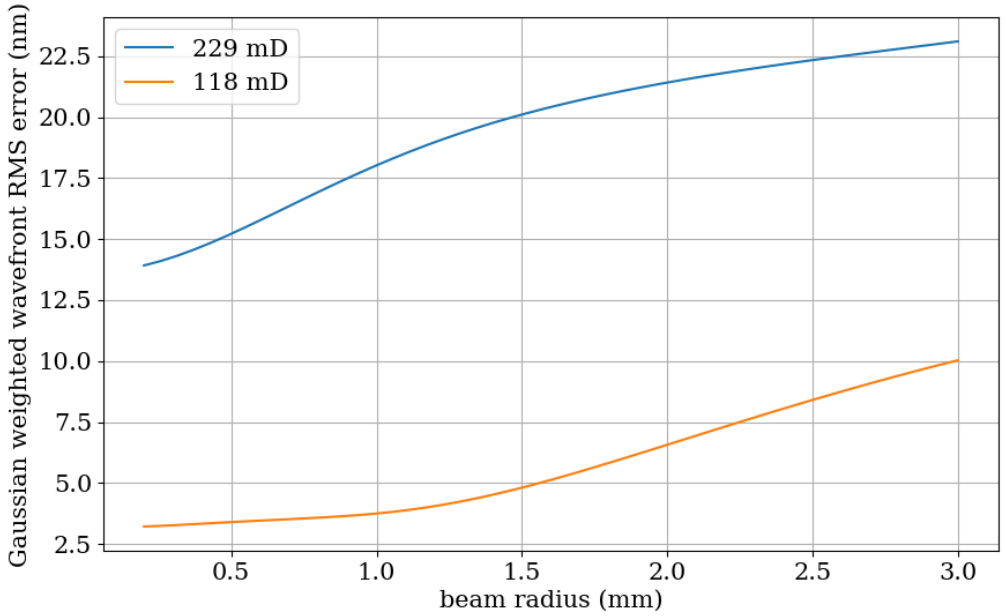


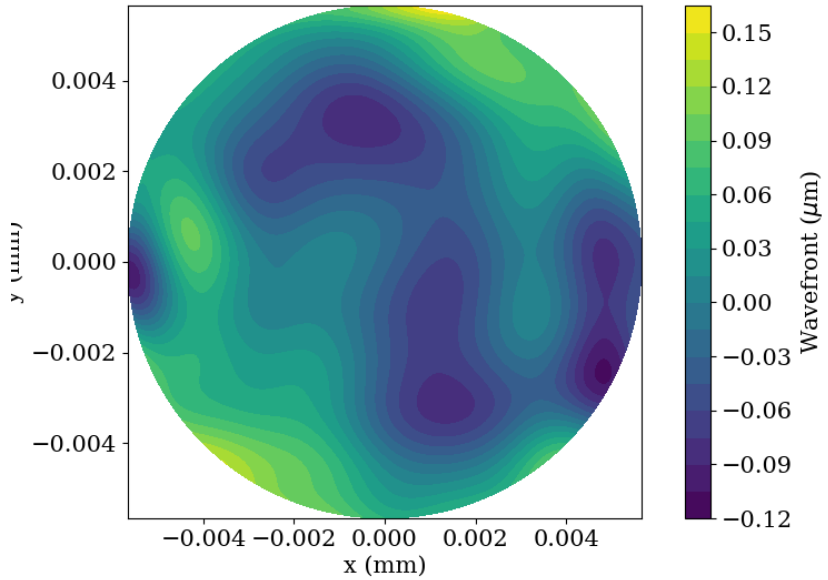
2. Residual wavefront map: deviation from best fit sphere – mainly high higher spatial frequency aberration





1. 2” CFM: low wavefront RMS error





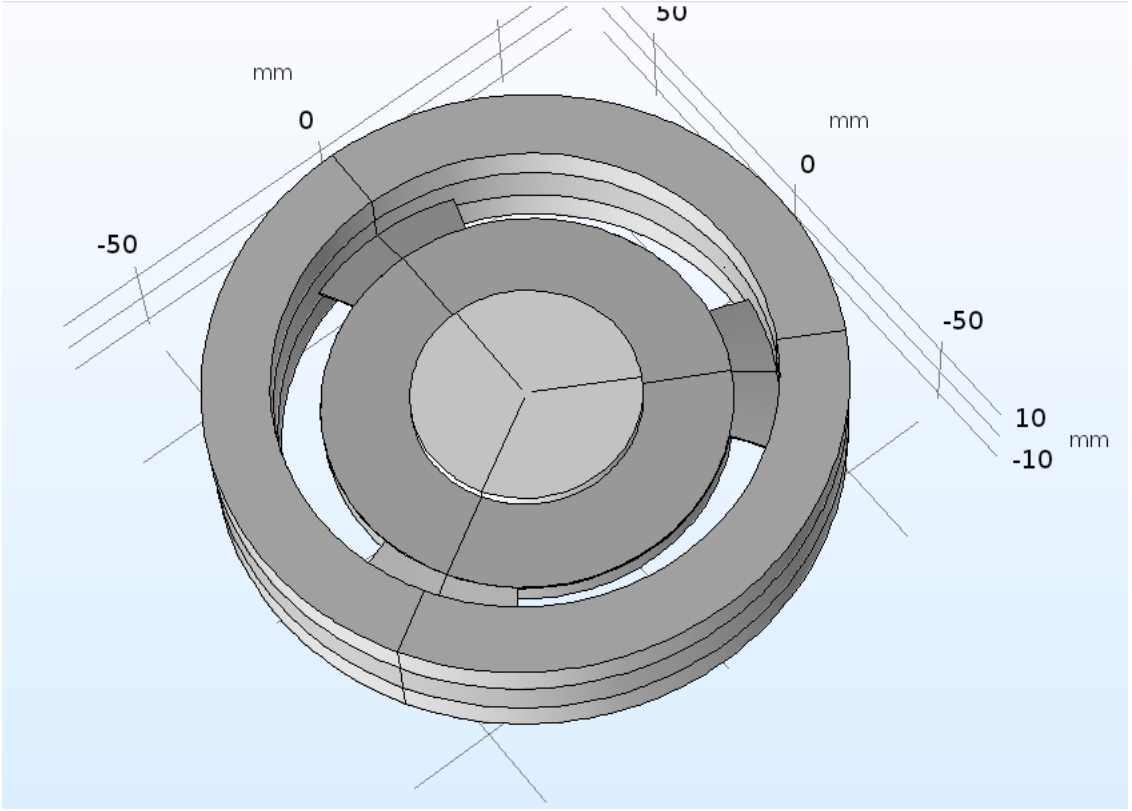
Computed Gaussian-weighted WF rms error vs beam width (left) from residual deviation map (left)

- WF RMS error:$\sigma = \sqrt{\langle TEM00|(\Delta W - \overline{\Delta W})^2|TEM00\rangle}$
- Recall requirement: < 5nm,:
  - At 120 mD, requirement is met for beam of radius up to 1.5 mm
  - At 230 mD deformation, WF rms error is higher than requirement

  → Compute RMS error for different beam size at various actuation level

2. 2” CFM testing plan

- Current 2” flat CFM:
  - Stability at constant temperature
  - Extended period performance
  - Cycle through multiple cycles
- 2” plano-concave still requires testing
- Investigate coating to improve emissivity for faster time constant
- New 2” flat mirrors from Thorlabs arrived
  - 1 kg baseline CFM
  - CFM with copper ring
  - CFM with flexure holder (*left*) :
    - Improve thermal isolation
    - Meet mass requirement without adding mass to actuating ring → faster thermal constant
    - Angle + position of flexures can be optimized to reduce effect of shifting in center-of-mass coupling into tip –motion



3. 2” CFM estimation of thermal noise

- Estimated Brownian thermal noise for different configuration using FEA for 1mm beam
- Assume constant loss angle for now (1e-7 for fused silica, 1e-4 for aluminum and stainless steel)
- Still below thermal noise of current tip-tilt stage, given by the HAM-ISI table motion filtered by a single-stage pendulum with a resonant frequency around 10Hz [G1601390 - page 4]
- Investigating effect of thermal noise on mirror curvature noise??

