# The impact of the differential arm length servo on photon calibrator comparisons

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**Abstract.** The detectors of the Laser Interferometer Gravitational-Wave Observatory (LIGO) are enhanced Michelson interferometers with four-km-long arms and 40 kg suspended mirrors. They detect differential arm length (DARM) fluctuations as small as $10^{-19}$ m. A DARM servo maintains the interference condition and the servo error point and control signals are used to compute relative length changes induced by gravitational waves. To provide accurate absolute calibration, a Photon Calibrator (Pcal) system has been implemented at the end of each interferometer arm. By leveraging the insensitivity of the interferometer to which arm length is changing, calibration uncertainty can be reduced by comparing Pcal fiducial displacements at two closely separated frequencies using a signal from the DARM servo. This comparison has been calculated continuously using the reconstructed *external* length variation signal by the LIGO group at Kenyon College since the beginning of the ongoing O4 observing run. Drifts as large as 0.2 % were observed in the LIGO Hanford Observatory (LHO) data over a year-long interval. To investigate the potential impact of changes in the DARM servo response at the two Pcal excitation frequencies, the Kenyon group also calculated the comparison using the DARM loop error signal. The ratio of the comparison calculated using the two methods yields the suppressed DARM loop sensing ratio. Data from May 2023 that includes the first six days of the ongoing O4 observing run reveal that the relative changes in the ratio of the response of the DARM servo at the two Pcal excitation frequencies were smaller than 0.0022 %. This may indicate that DARM servo response variations are not a significant contributor to the 0.2 % drifts observed in the Pcal calibration comparison factor. Efforts to extend this investigation to the rest of the O4 run data are ongoing.