Erratum: Expanding the Quantum-Limited Gravitational-Wave Detection Horizon [Phys. Rev. Lett. 134, 051401 (2025)]

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This erratum reports two errors found, respectively, in the Finesse 3 codebase used for modeling the LIGO detectors [1] and in the corrective heating profile applied to the compensation plates, both of which affect the results of this Letter.

The first of the two errors is a bug discovered in the Finesse 3 source code. A utility method used to calculate a given mirror map's rms wave front error, weighted by the Gaussian intensity profile of the incident laser beam [defined in Eq. (4) of Ref. [2]], inadvertently weighted the calculation by the beam's *amplitude* profile rather than its intensity profile. This led to suboptimal thermal compensation system (TCS) actuator power levels in the published article, since these powers are chosen so as to minimize the rms wave front errors. The second error reflects a mistake in the intensity profile of the 10.6 μm heating laser applied to the compensation plates. An idealized intensity profile was used (a perfect inverse of the laser beam-heating profile), rather than the *actual* annular intensity profile used by Advanced LIGO (shown in Fig. 12 of Ref. [2]).

The introduction of these errors affects the interferometer projections only marginally, because the effects of the two corrections largely offset each other. Our updated projections for a LIGO A+ interferometer are shown in revised Figs. 1 and 2. For a fixed input laser power of 125 W and an effective injected squeezing level of 9 dB, we obtain a maximum noise floor reduction of 12% from 200 to 5 kHz. We still obtain a net increase of 4 Mpc in the sky-averaged detection range for binary neutron star mergers (the higher shot noise, at high frequencies, is countered by lower radiation pressure noise at low frequencies). Table I lists the revised TCS actuator power levels for each case considered.

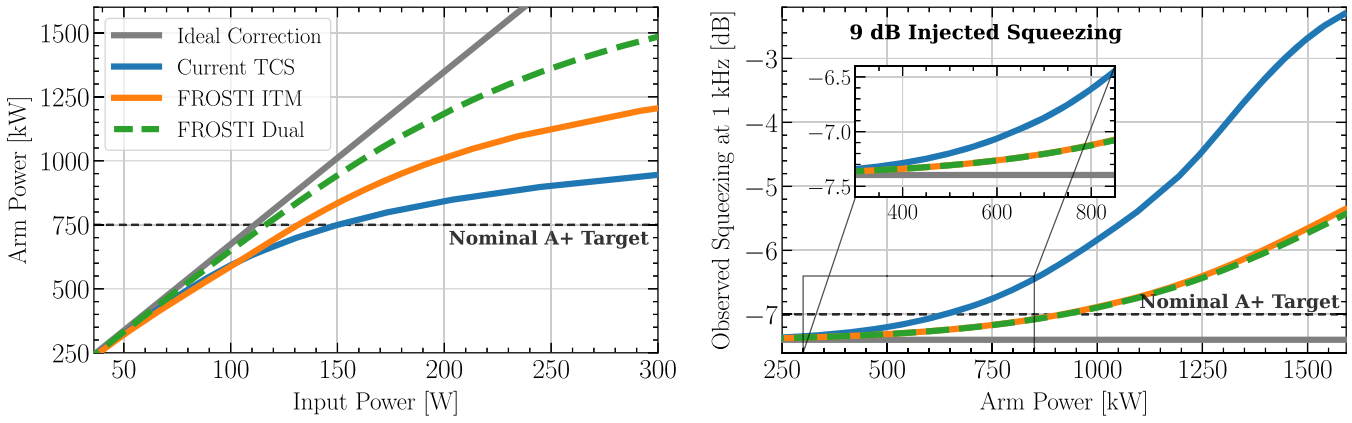


FIG. 1. Left: achievable arm cavity power with increasing input power in the LIGO A+ detectors, under different thermal compensation scenarios. Right: achievable squeezing (quantum noise reduction) with increasing arm power. In all cases, 9 dB of effective frequency-dependent squeezing enters the interferometer and the resulting observed squeezing is shown at 1 kHz.

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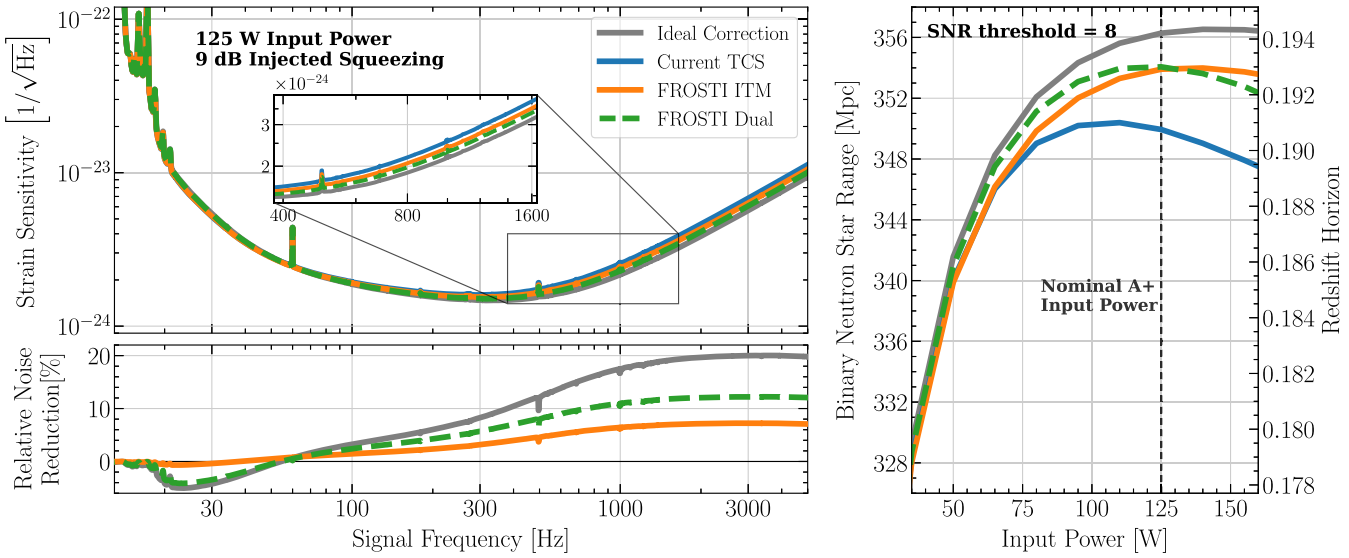


FIG. 2. Left: projected strain sensitivity (top) and relative sensitivity improvement (bottom) of the LIGO A+ detectors with 125 W of input laser power and 9 dB of effective injected squeezing, under different thermal compensation scenarios. The noise improvements in the bottom panel are calculated relative to the case of LIGO's current thermal compensation system (TCS). Right: astrophysical impact of the FROSTI-enabled quantum noise reduction in terms of binary neutron star detection range and the corresponding cosmological redshift horizon, as a function of increasing input power.

TABLE I. Optimal TCS actuator power levels, in units of watts, for the actuation cases shown in the left panel of Fig. 2. Abbreviations: ring heater (RH); compensation plate (CP).

	Actuator				
	ITM			ETM	
Case	FROSTI	RH	CP	FROSTI	RH
Current TCS	···	16.6	4.9	···	6.6
FROSTI ITM	1.7	17.1	3.0	···	7.0
FROSTI dual	1.9	19.1	3.4	2.2	11.4

[1] D. D. Brown, A. Freise, H. T. Cao, A. Ciobanu, J. Gobeil, A. Green, P. Hapke, P. Jones, M. van der Kolk, K. Kuns, S. Leavey, J. W. Perry, S. Rowlinson, and M. Sallé, Finesse (2025), 10.5281/zenodo.12662017.
[2] A. F. Brook *et al.*, Overview of advanced LIGO adaptive optics, Appl. Opt. **55**, 8256 (2016).