E3/E4 Displacement Sensitivity Calibration for the LLO 4km IFO

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Detector Characterization Session

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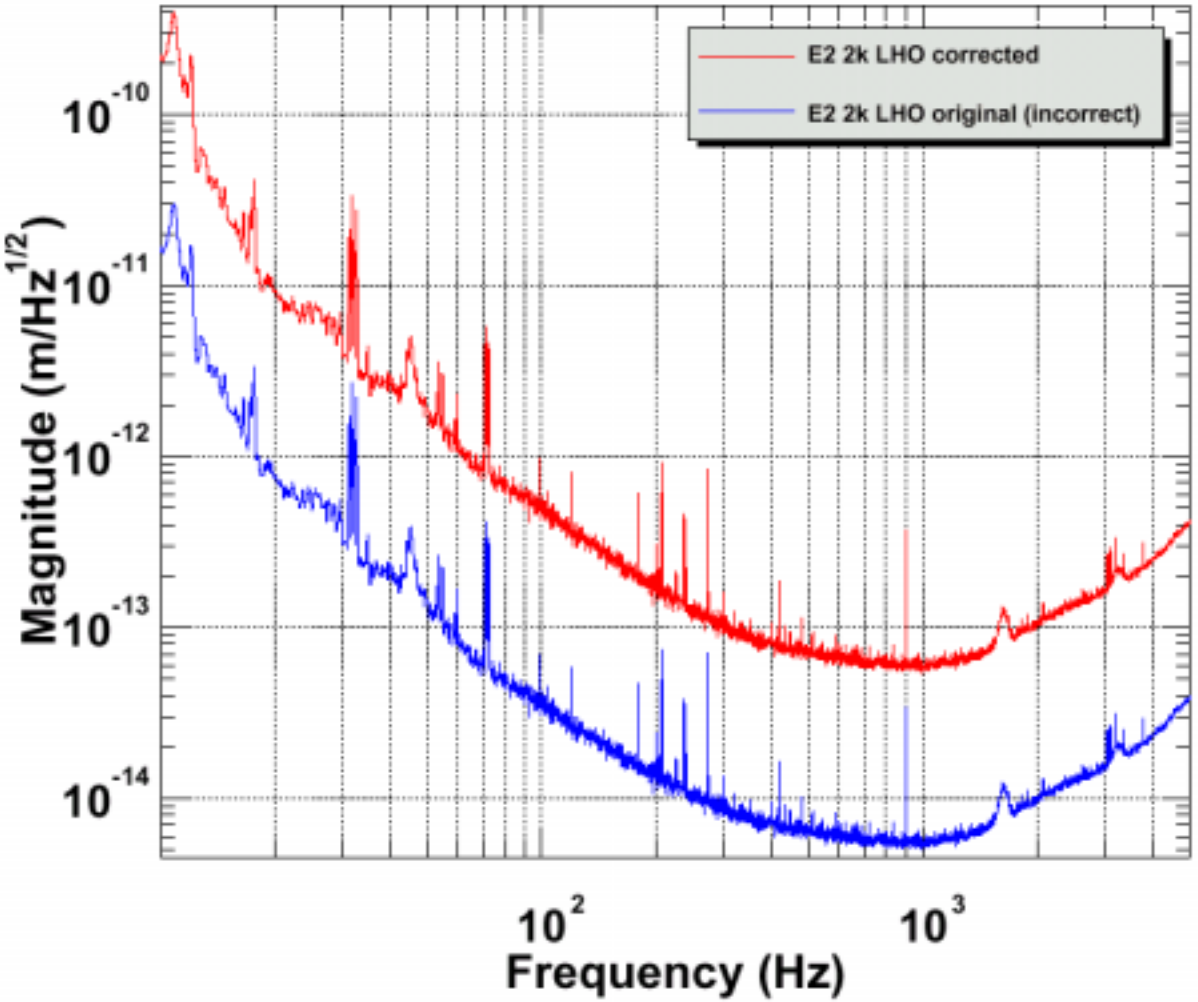
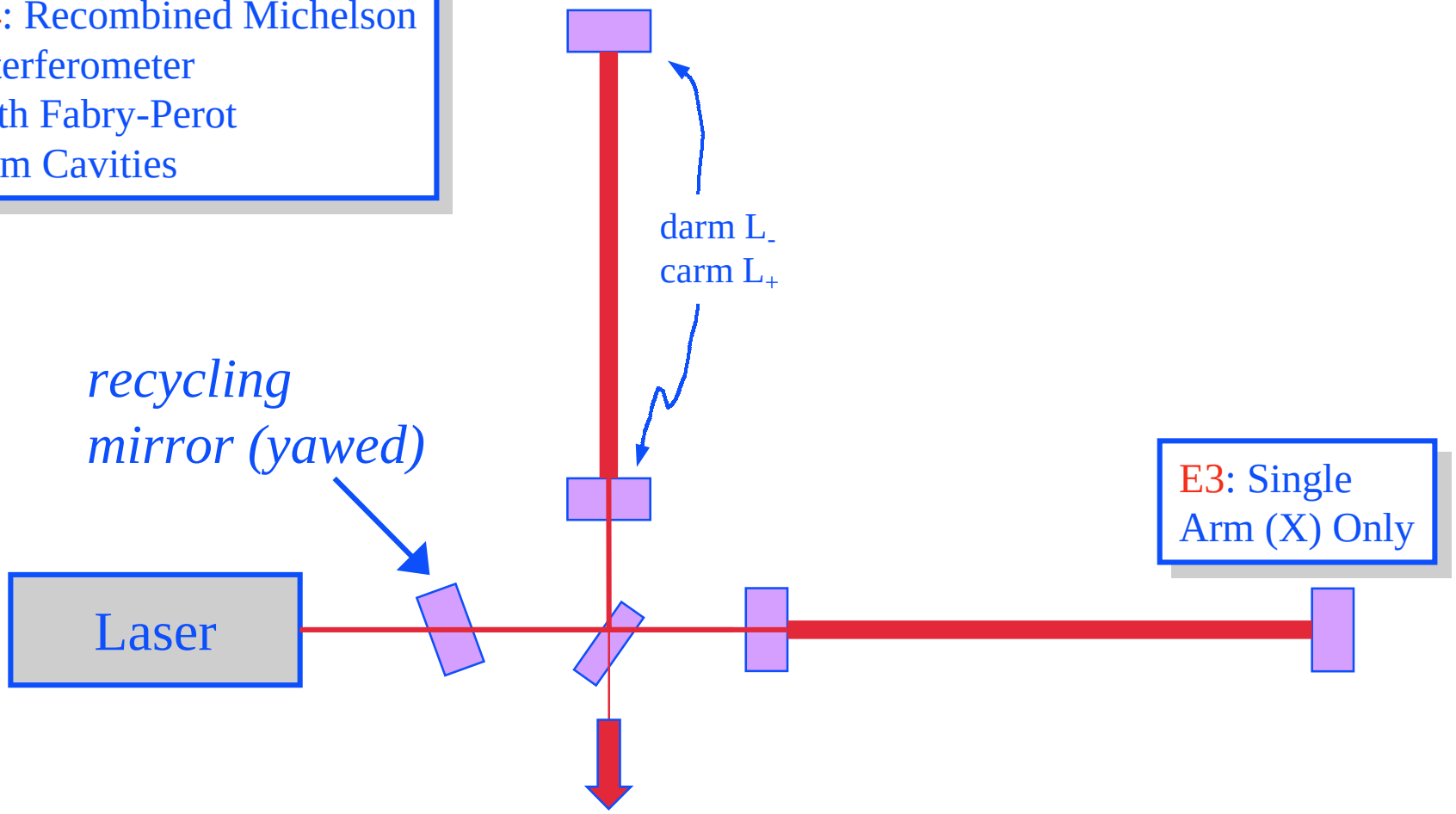
Revised E2 curve

- No other calibrations for E2 affected (ITM's ETM's, CARM, DARM)
- Original calibration agreed with independent Oct. 30 version (bad ETM calibration)
- Current recycled IFO shows factor of 200x improvement over E2 corrected noise curve
- Increased power on the beamsplitter,
- recycling factor ~15
- Whitening filters used in recent noise curves



LLO interferometer control

E4: Recombined Michelson Interferometer with Fabry-Perot Arm Cavities



E4 ITM calibration

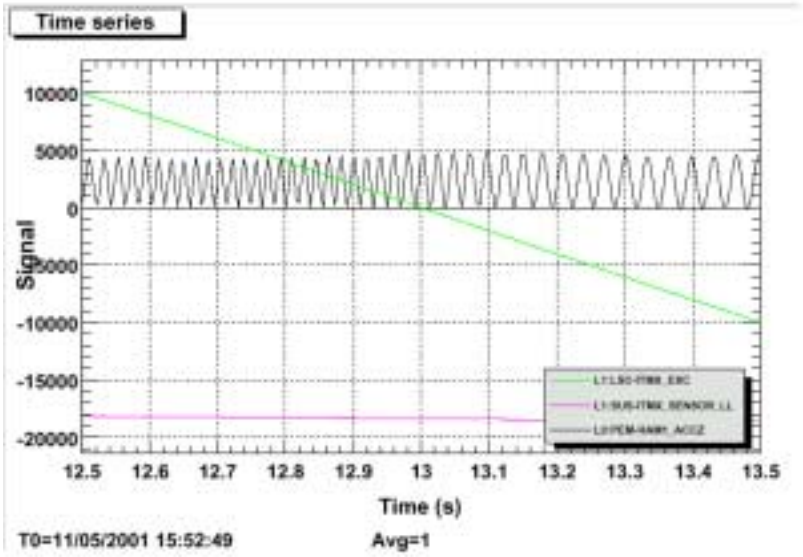
•Basic idea: drive mass with known force and measure displacement

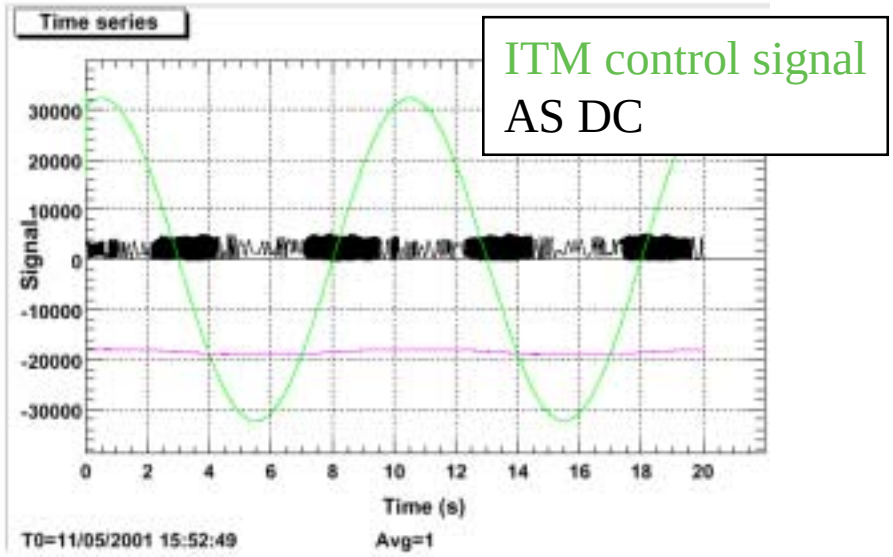
•Drive the ITM with a slow sinusoid (0.1 Hz) and count the number of fringes that are read out at the antisymmetric port.

Calibrations for the ITM's are then

α_{ITMX} = 1.06 +/- 0.05 nm/count

α_{ITMY} = 0.98 +/- 0.05 nm/count

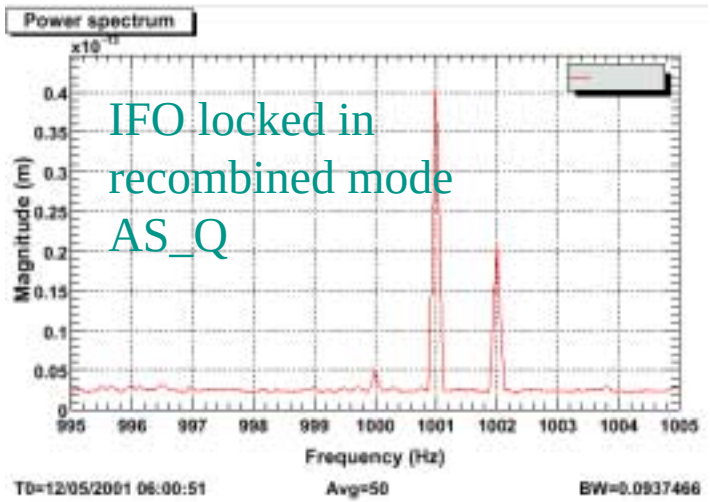




ETM calibration

To extrapolate the calibration of the input test masses (ITM's) to the end test masses:

Assuming identical coil drivers (E1=E2) and pendulum transfer functions (P1=P2), and using equal excitations on both masses,



$$\alpha_{\mathrm{ETM}} = \frac{error\_signal(f_{\mathrm{ETM}})}{error\_signal(f_{\mathrm{ITM}})}\alpha_{\mathrm{ITM}}$$

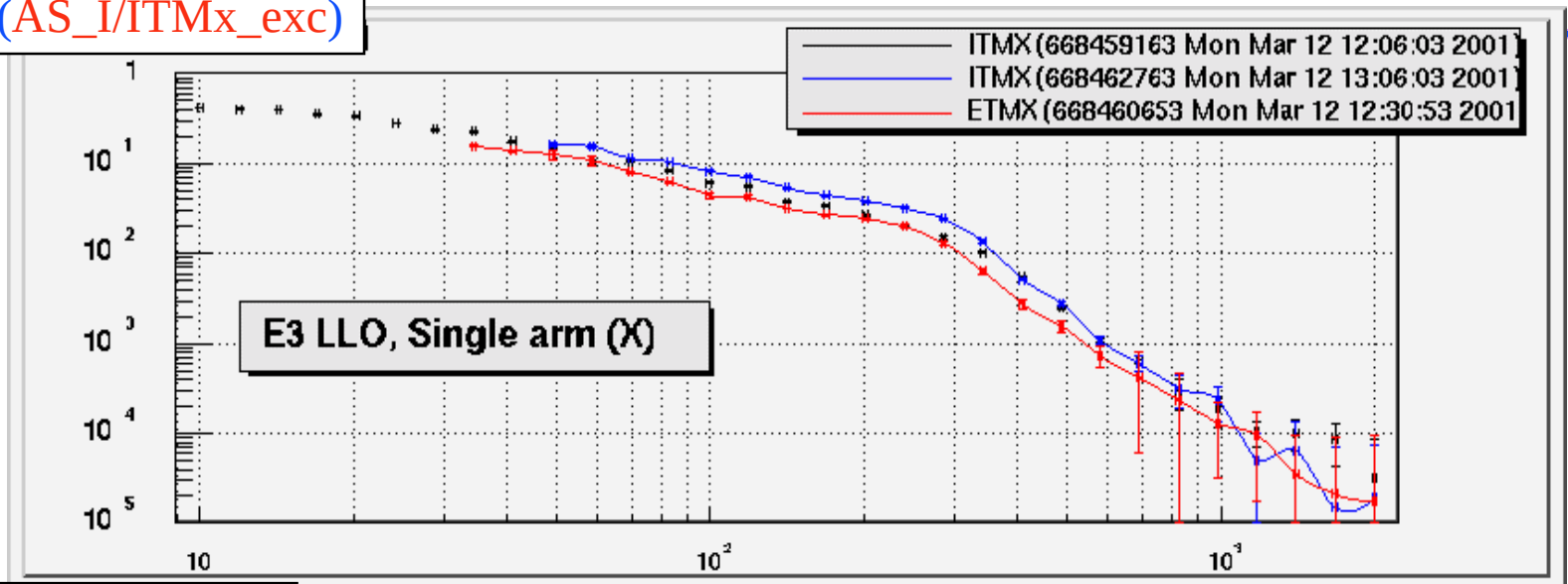
Calibrations for the ETM's are then

α_{ETMX} = 0.56 nm/count

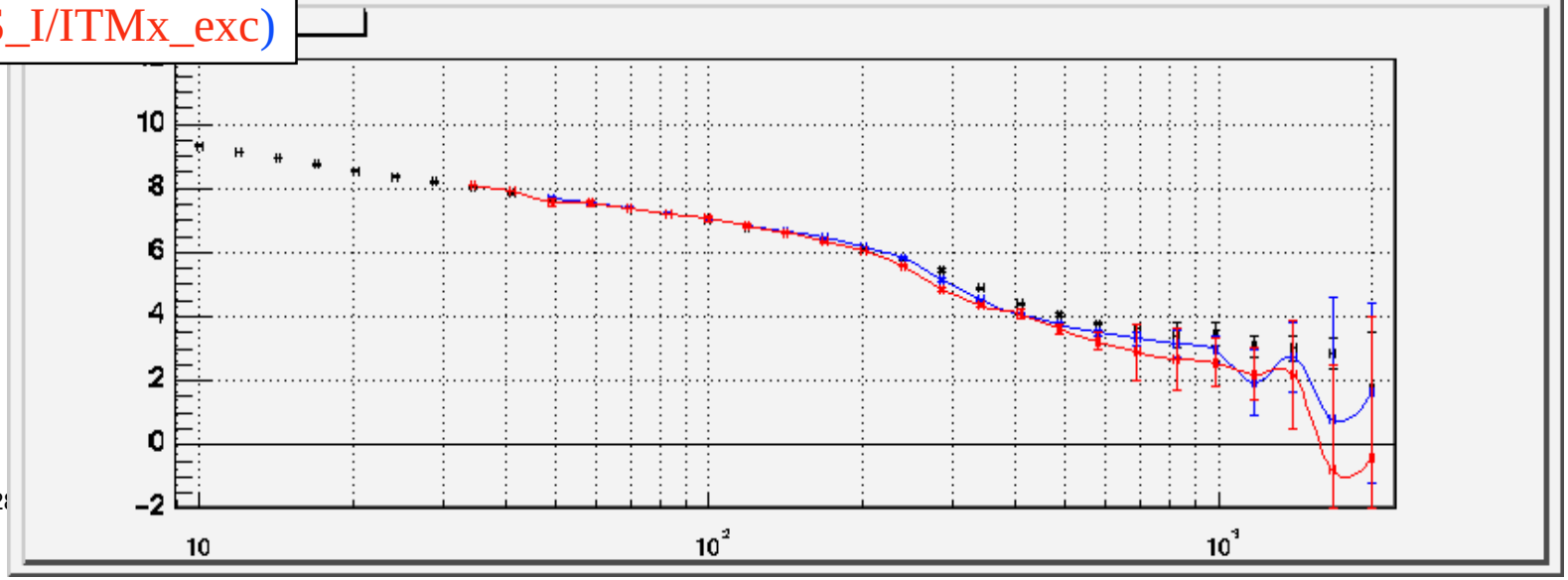
E3 Transfer function

- sweep test mass, take transfer function between AS error signal and excitation

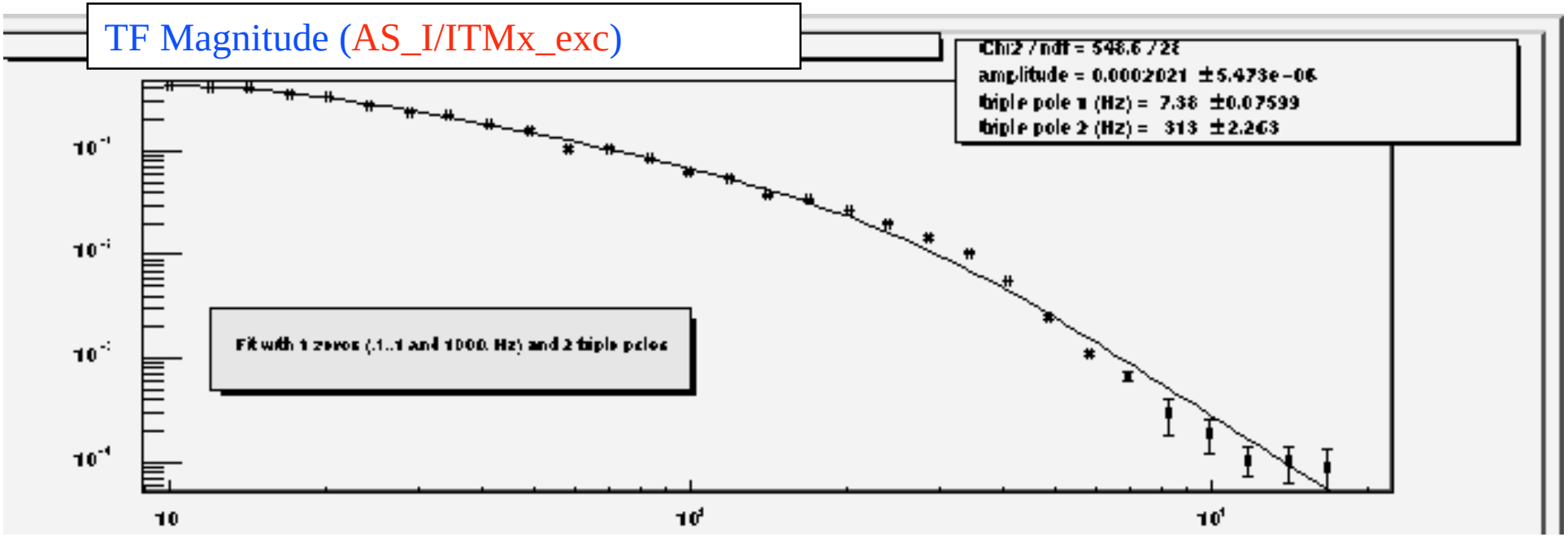
TF Magnitude (AS_I/ITMx_exc)



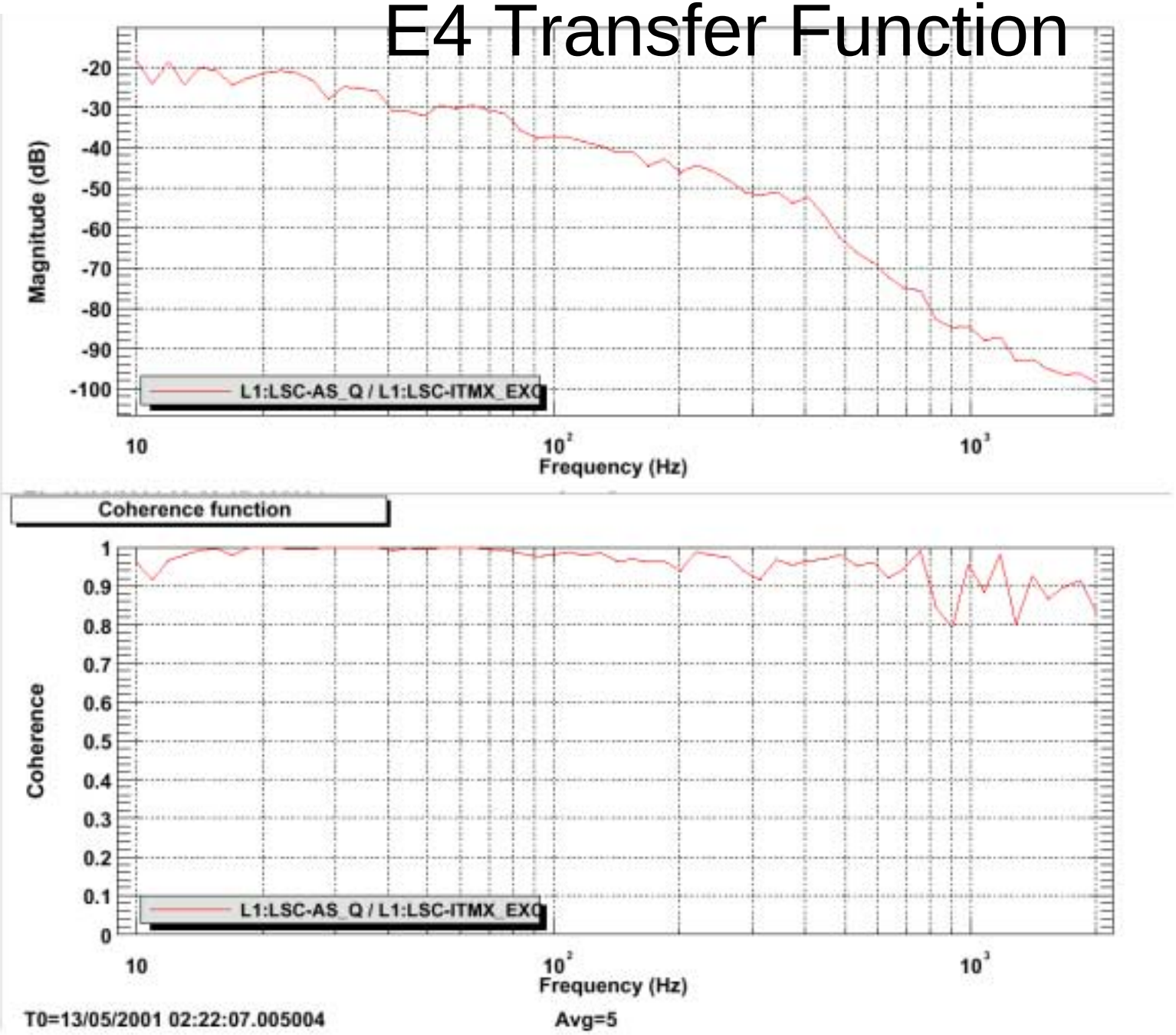
TF Phase (AS_I/ITMx_exc)



E3 Fit parameters



E4 Transfer Function

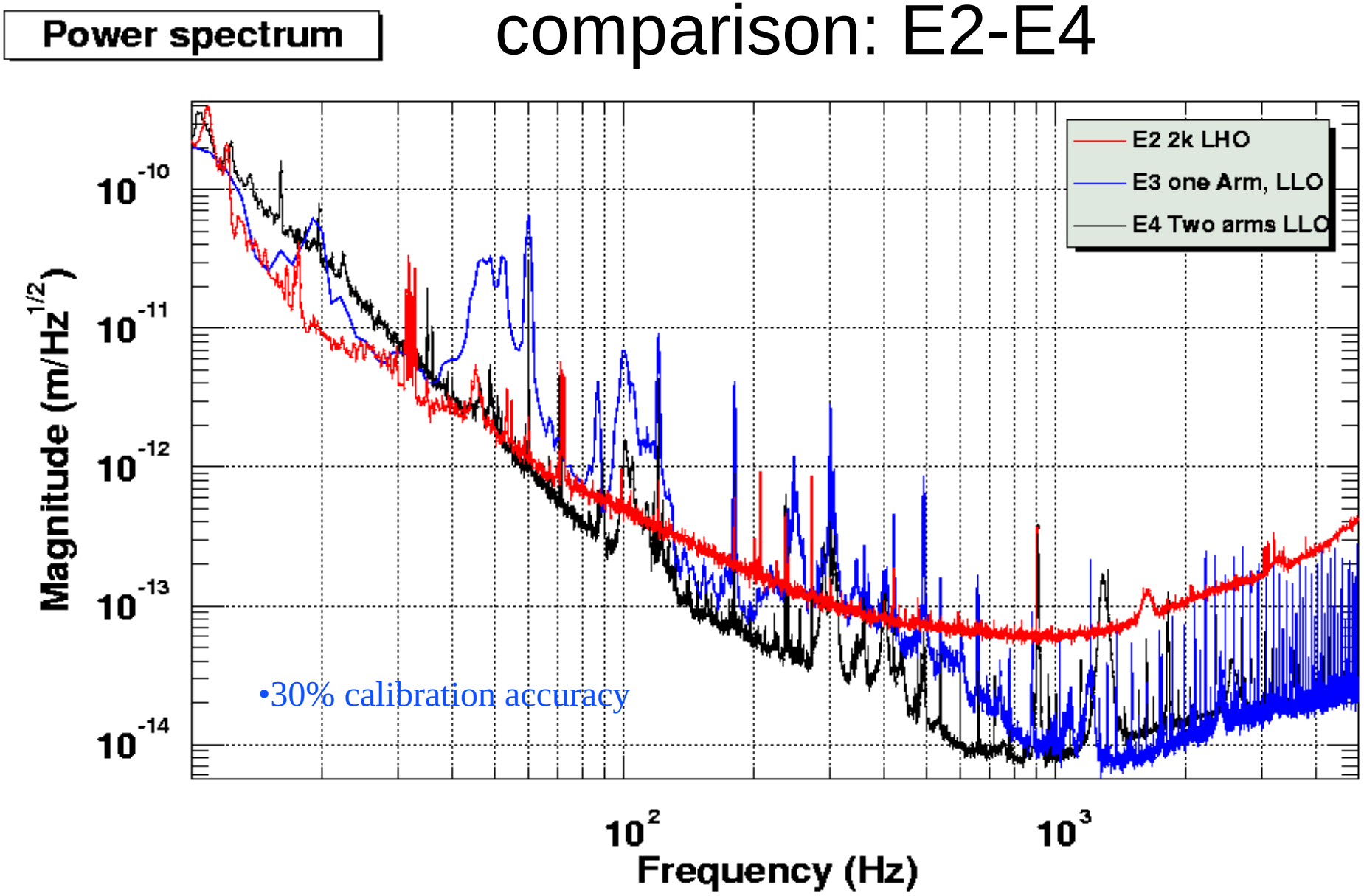


Calibration parameter summary

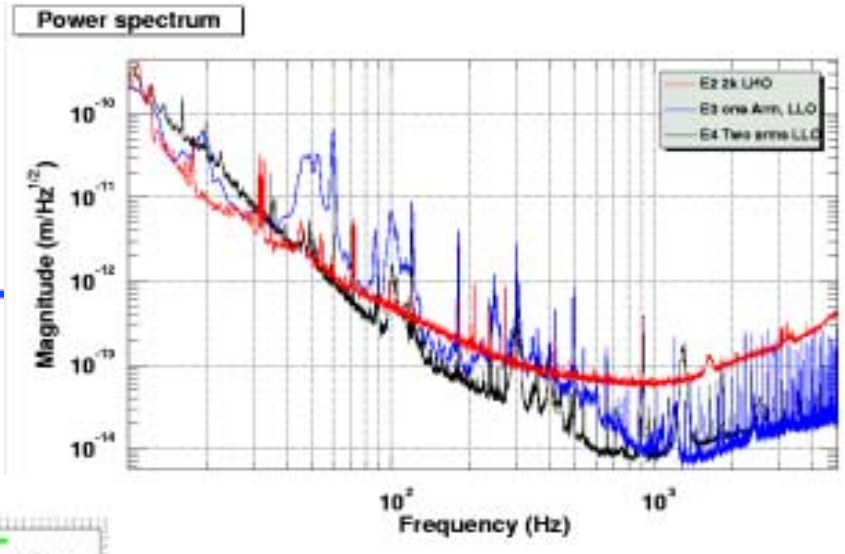
Run	Gain	Poles (Hz)	Zeros	Channel to use
E2 (LHO 2k)	6.8e-8	0.74, 0.74, 0, 0	50.35, 50.35, 12.1, 12.1, 186	H2:LSC-AS_Q
E3 (LLO one arm)	4.9e-6	0.74, 0.74, 0.1, 0.1, 1000	7.38, 7.38, 7.38, 313, 313, 313	L1:LSC-AS_I
E4 (LLO two arms)	1.69e-9	0.74, 0.74, 0, 0,	16.82, 0.391, 0.391, 232.6, 232.6	L1:LSC-AS_Q

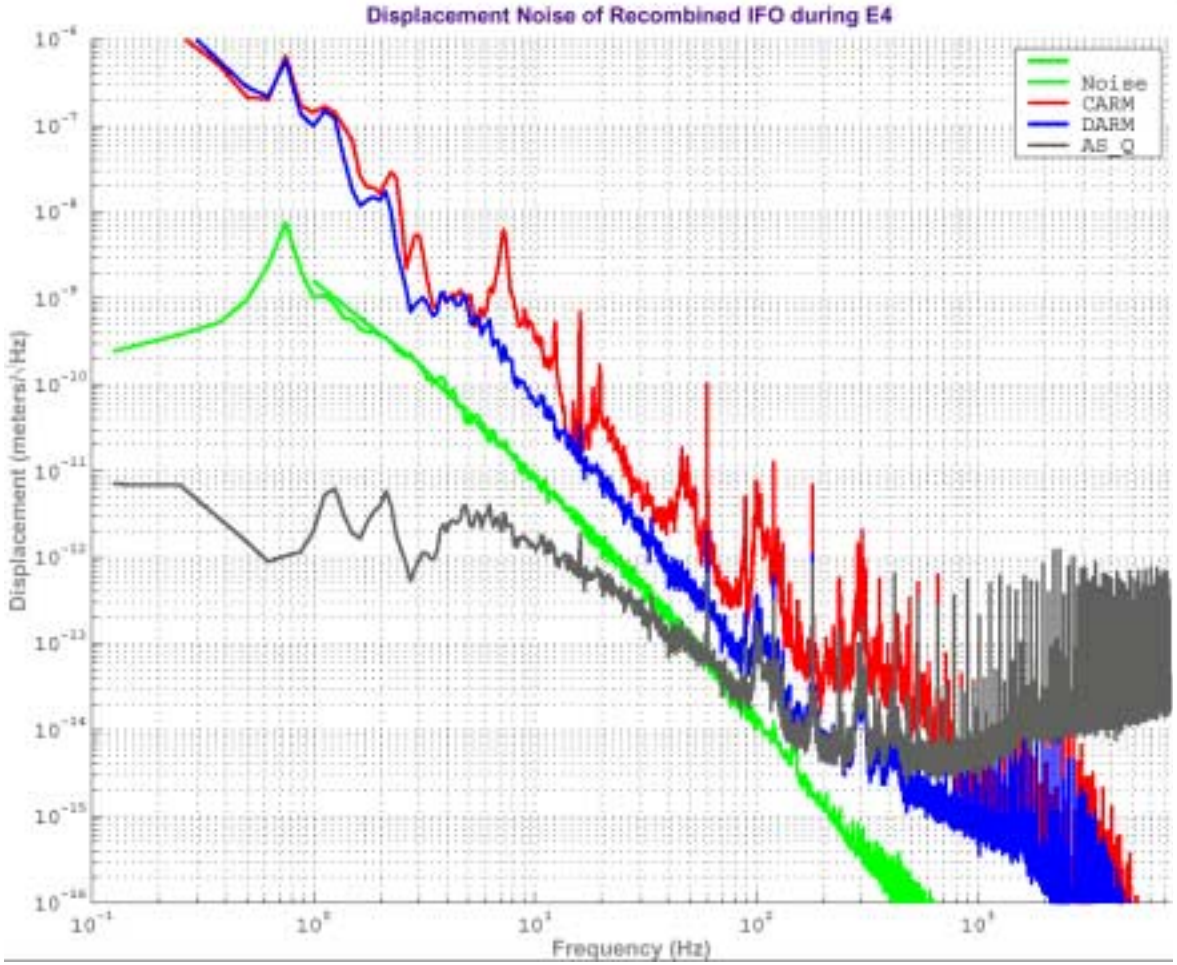
Except for the double pole at 0.74 Hz (mirror pendulum) the poles and zero are the result of a transfer function fit.

Displacement sensitivity comparison: E2-E4



E4 Noise curve comparison



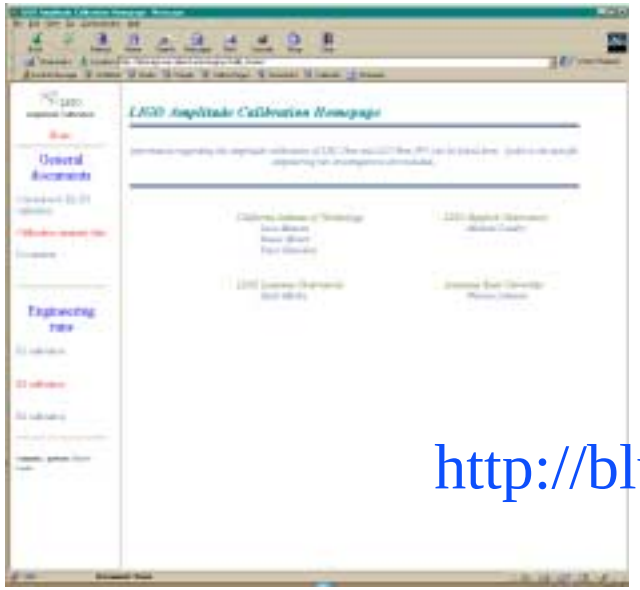


Quasi-independent calibration by Rana's frequency noise group

http://blue.ligo-wa.caltech.edu/engrun/E4/Results/LengthNoise/

Summary

- Correction issued to E2 calibration
- Recombined LLO IFO best sensitivity during E4 was approximately 8×10^{-15} m/Hz$^{1/2}$ at 1kHz
- Stability of calibration not well tested as test points, sweeps difficult to implement
- Transfer functions each of the four masses look very similar
- E2, E4 recombined noise curves within a factor of 10; whitening filters engaged at LLO



Amplitude calibration homepage:
http://blue.ligo-wa.caltech.edu/engrun/Calib_Home/