CHARACTERIZATION OF THE LHO 2KM CAVITIES

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LSC meeting

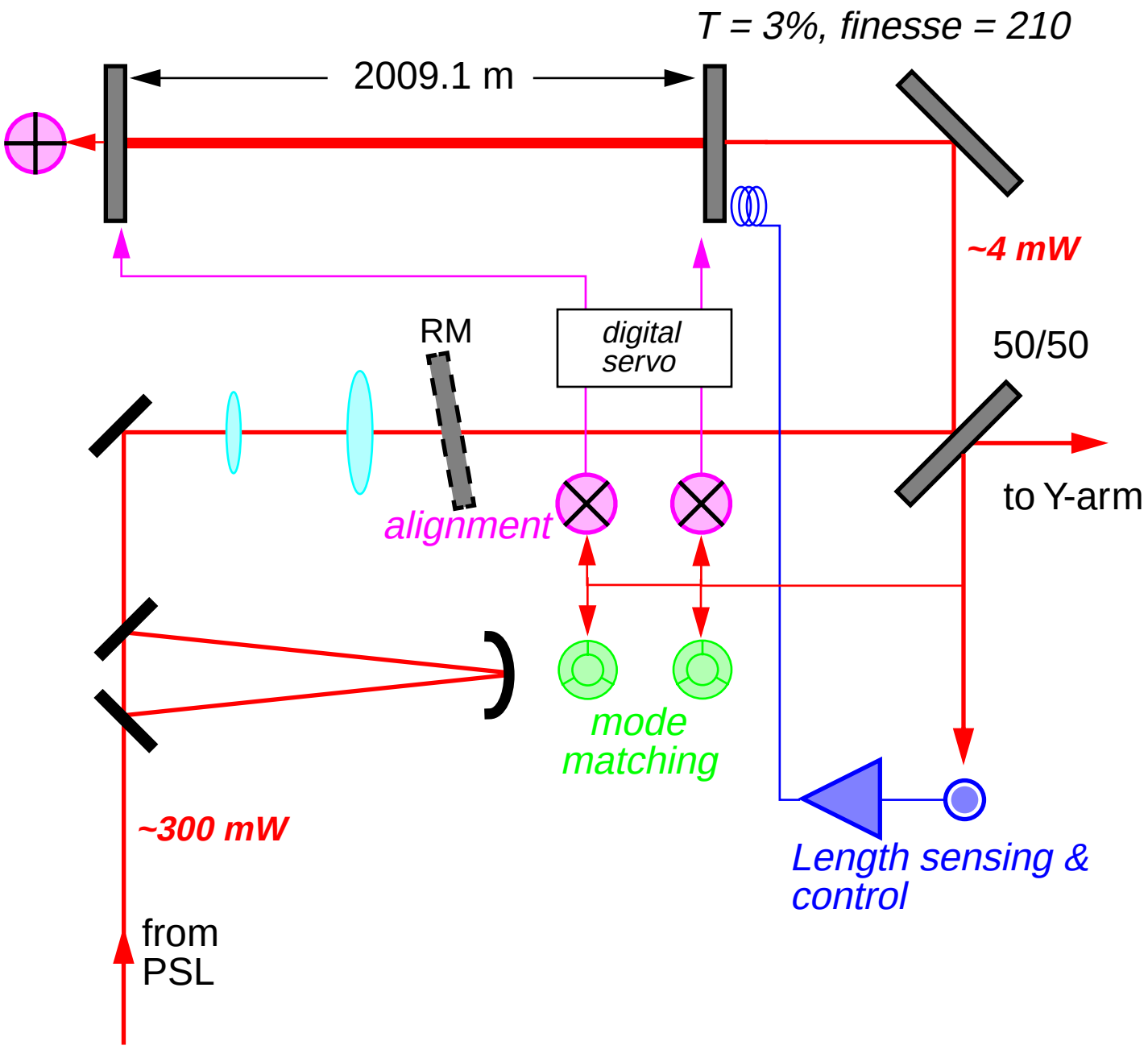
LLO, 16-18 March 2000

G000028-00-D

Goals

- Optical
  - Measure cavity resonant reflectivity (cavity losses)
  - Measure mode-matching; adjust telescope if necessary
- Environmental influences
  - Length fluctuations: microseism and tides
  - Angle fluctuations
- Servos
  - lock acquisition
  - test mass resonances
  - alignment servo (digital)
  - test final stage of frequency stabilization (common mode servo)
  - characterize stack fine actuators

2km X-arm



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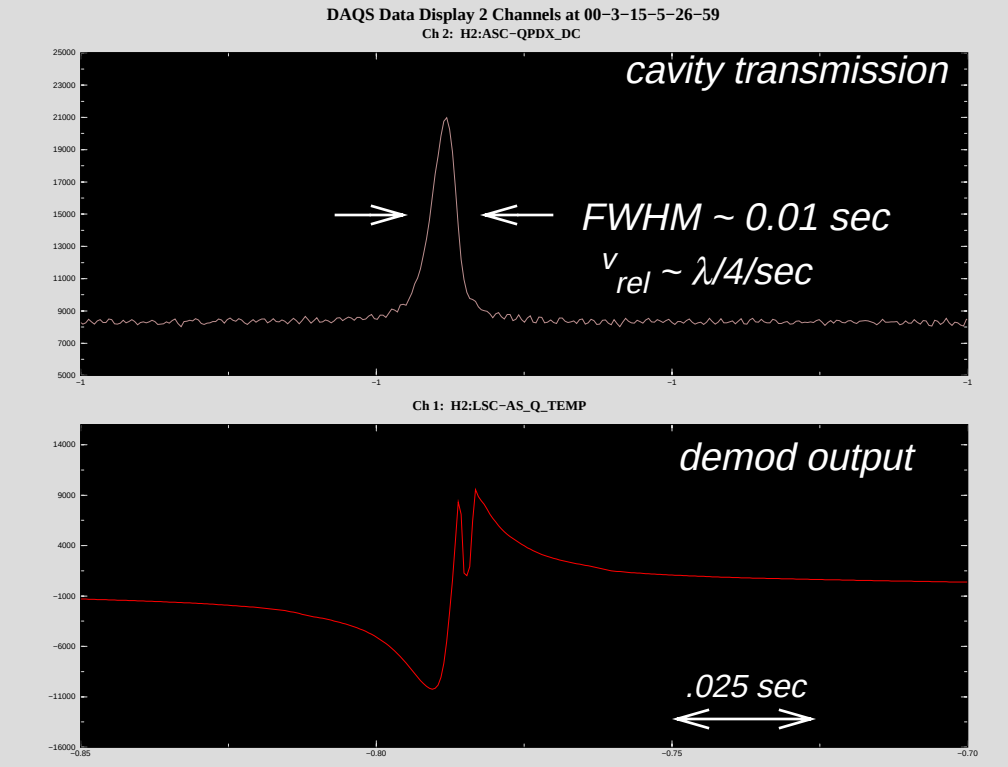
Status

- Gate valves between corner and mid stations first opened end Nov ‘99
  - laser beam scatter off of suspension cage was seen immediately!
- Most of the effort to date put into acquiring and maintaining a stable lock
  - since the end of Feb, cavity locks easily, and stably for 1-2 hours
- Wavefront sensor alignment system implemented in early March
  - clearly brings the cavity to good alignment
- Optical and environmental characterizations are underway
  - characterization will continue through first week of April

Cavity length locking

Cavity free-swinging (optics locally damped) through a resonance:



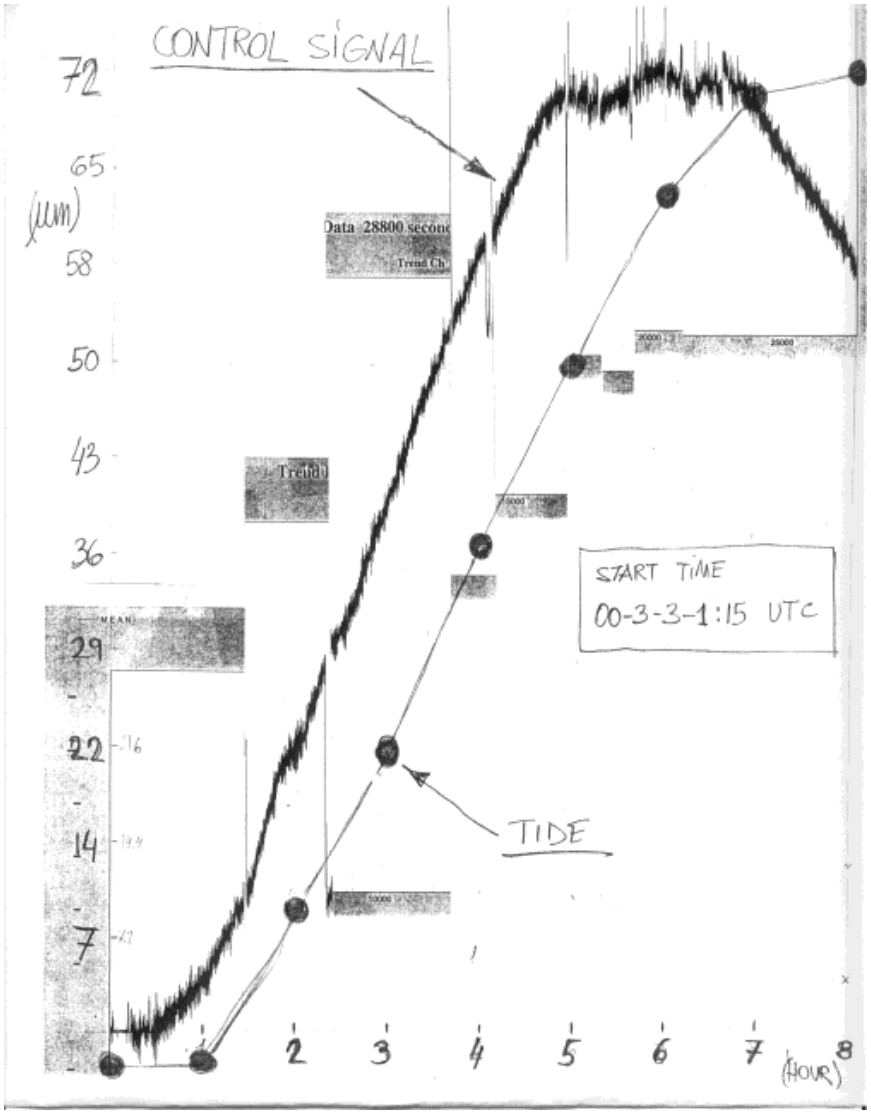
- Unity gain frequency: ~500 Hz
  - f > 30 Hz: 1/f
  - 1 Hz < f < 20 Hz: $1/f^3$
- Test mass resonances
  - initial strategy was to notch out the first two axisymmetric modes (9.4 kHz & 14 kHz)
  - didn't work: first non-axisymmetric (6.2 kHz) mode and many higher frequency (>20 kHz) modes rung up
  - solution: notch added at 6.2 kHz; loop roll-off above ~10kHz increased with additional poles

Cavity resonant reflectivity

- Current measurement: $P_{\mathrm{ref,res}} / P_{\mathrm{ref,nr}} = 96\ \%$
  - $$R_{\mathrm{cav}} \approx 1 - \frac{8L}{T} \Rightarrow L = (1 - R_{\mathrm{cav}})(T/8) = 150\ \mathrm{ppm}$$
- We expect more like 50 ppm losses
  - beam centering: an offset of the beam from the center of one of the test masses of 5 cm results in ~50 ppm of aperture loss; initially produced a higher loss, but not since realignment
  - beam may be clipping in non-cavity optical elements in the vacuum system
- Mode matching
  - intend to measure with wavefront sensing, ‘bull’s-eye’ photodetectors
  - examining the cavity reflected power transient when the input beam is cut off gives a lower limit of ~80%

Drifts

- PSL Reference cavity temperature
  - initially, 2km cavity length drifts of ~1 µm/min were seen
  - reference cavity chamber was temperature stabilized, to a small fraction of this rate
- Tidal distortions



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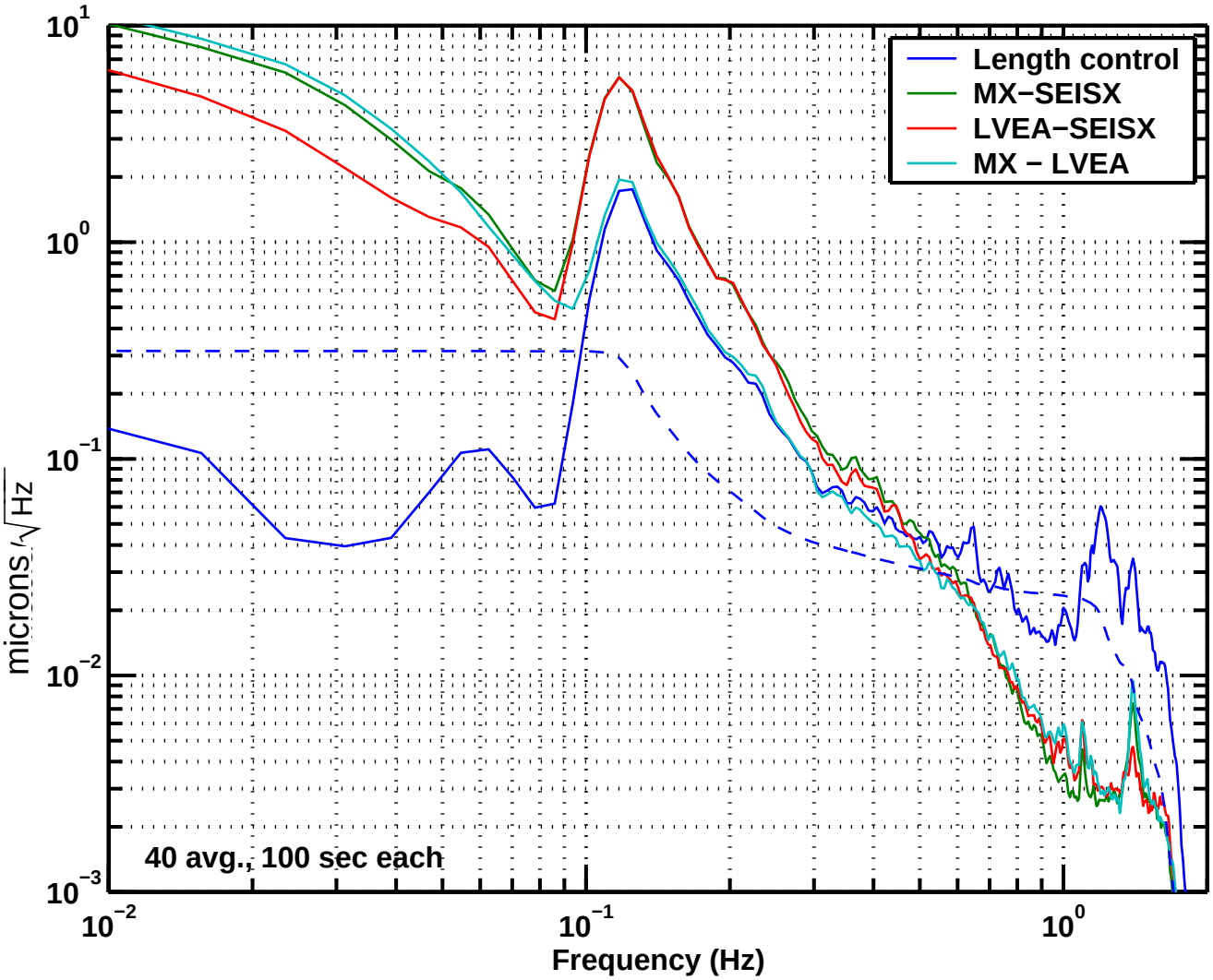
Microseism

- Comparison of cavity length control signal with seismometers
  - 4000 sec of data (continuous lock)



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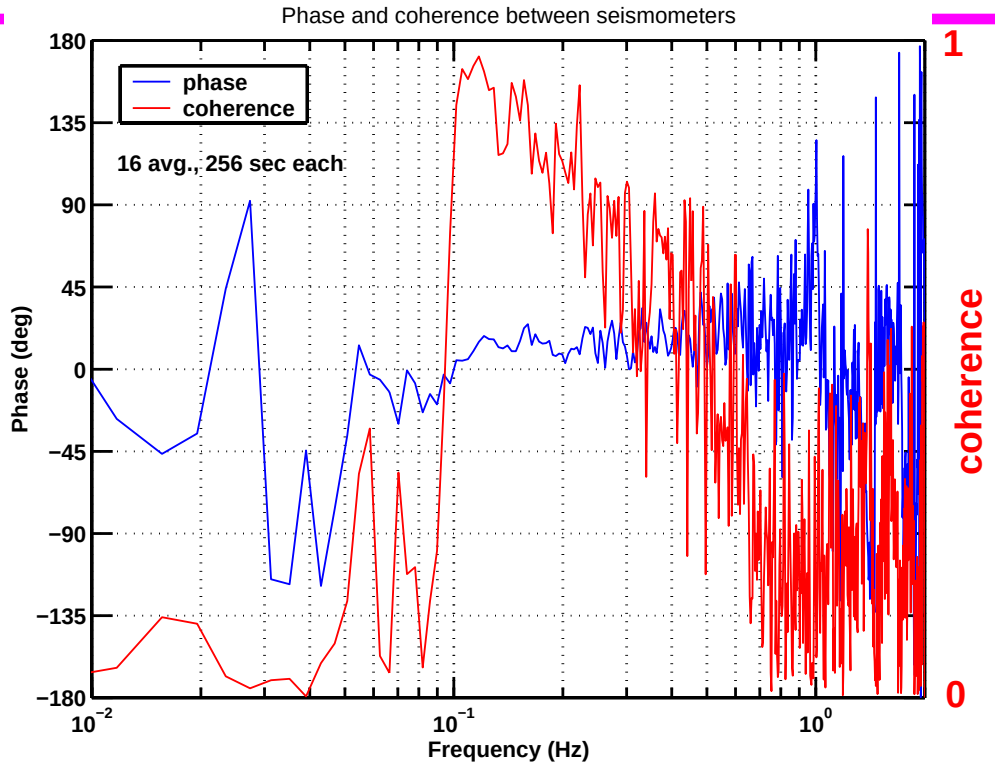
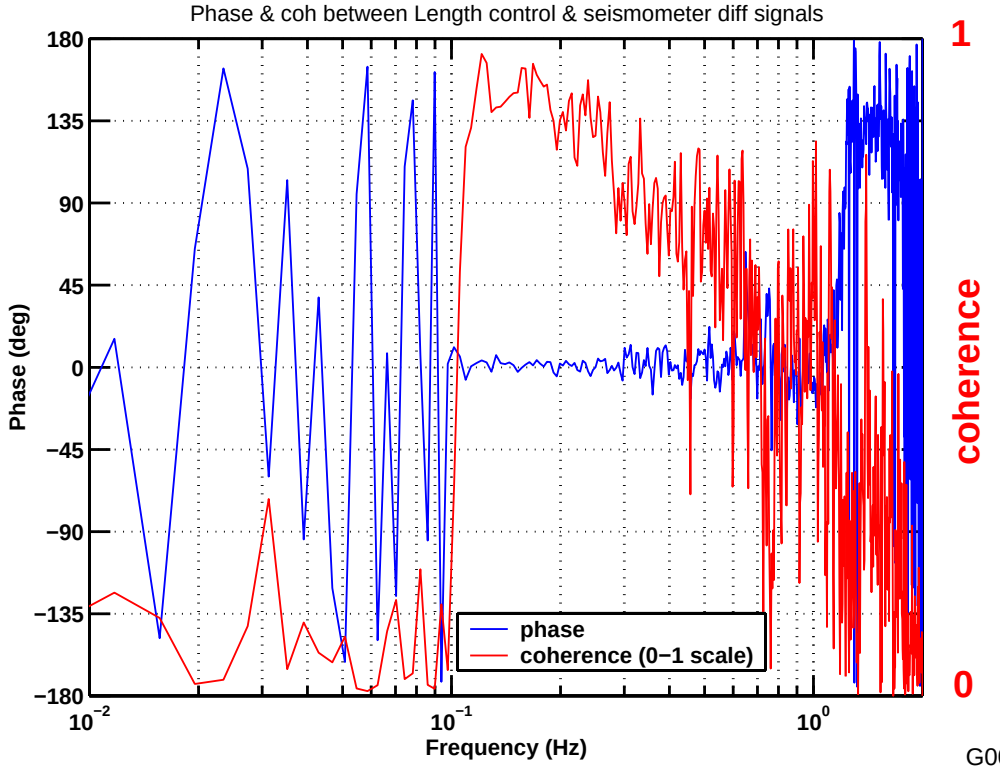
Microseism (cont'd)





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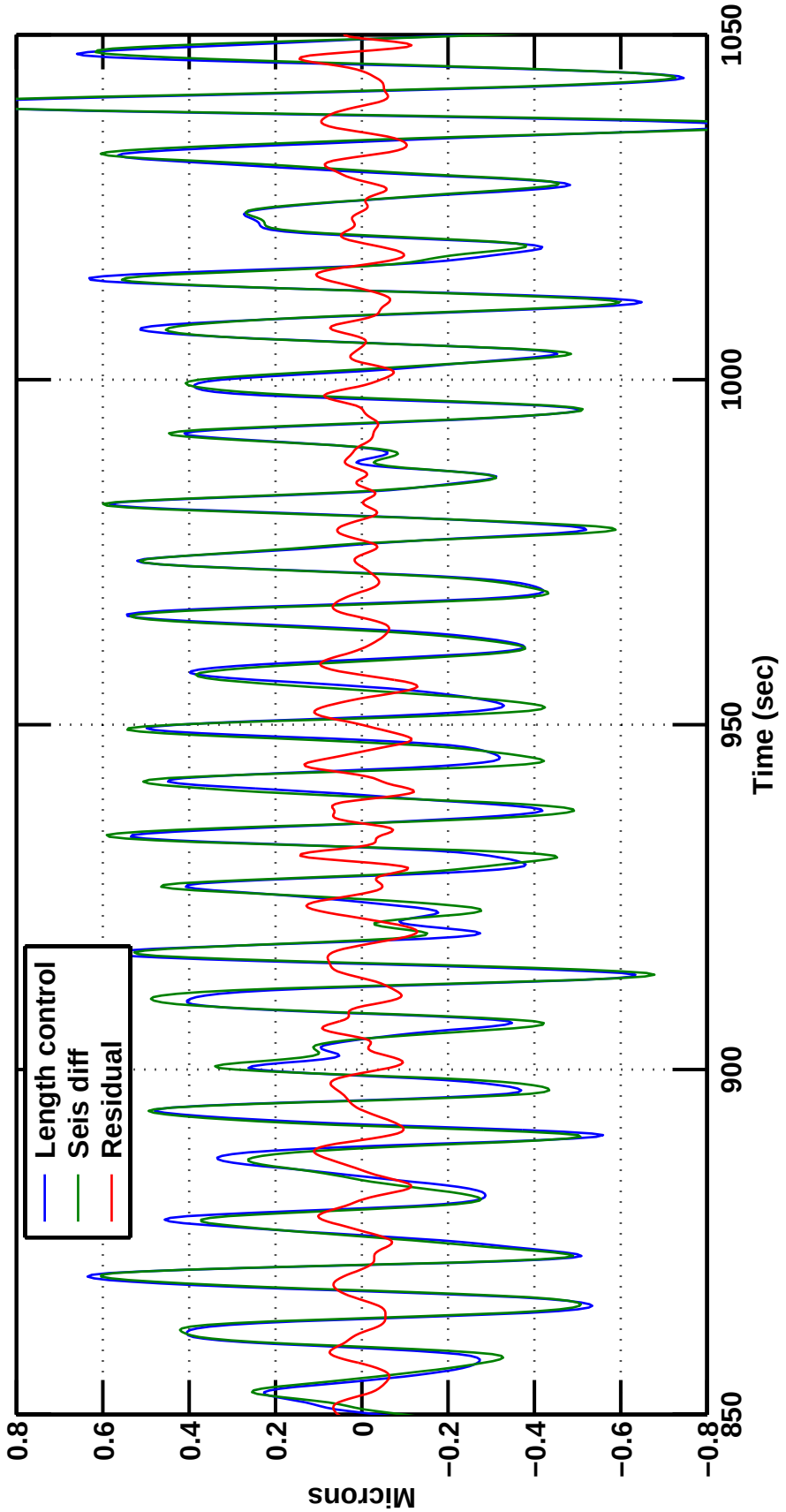
Length control
Seis diff
Residual
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
Microns
850
900
950
1000
1050
Time (sec)

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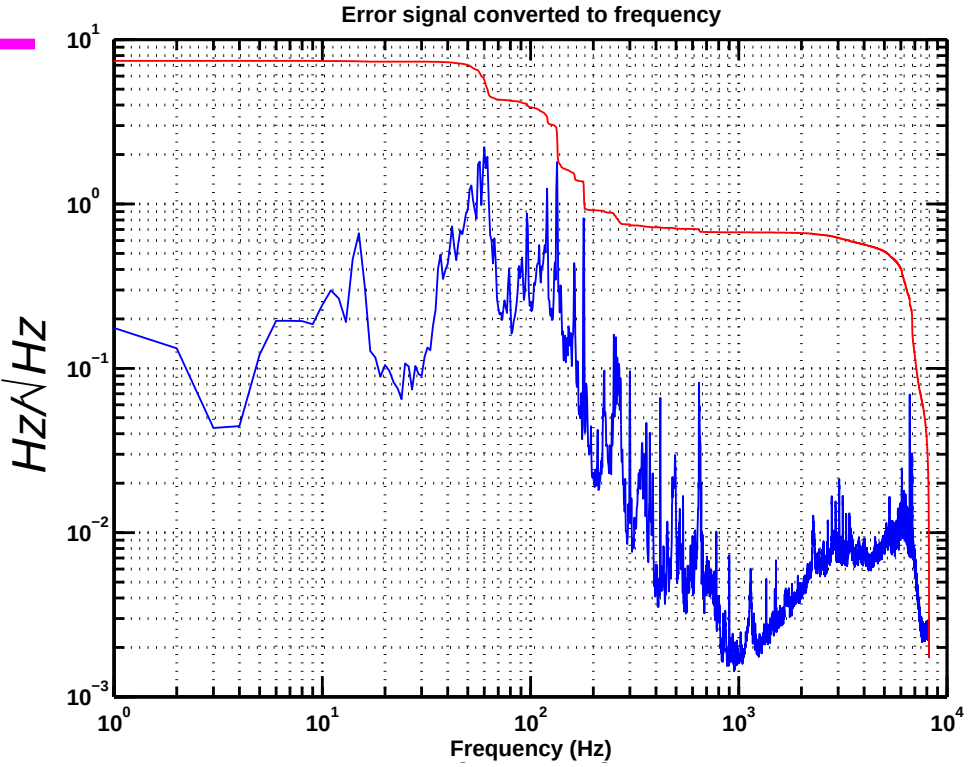
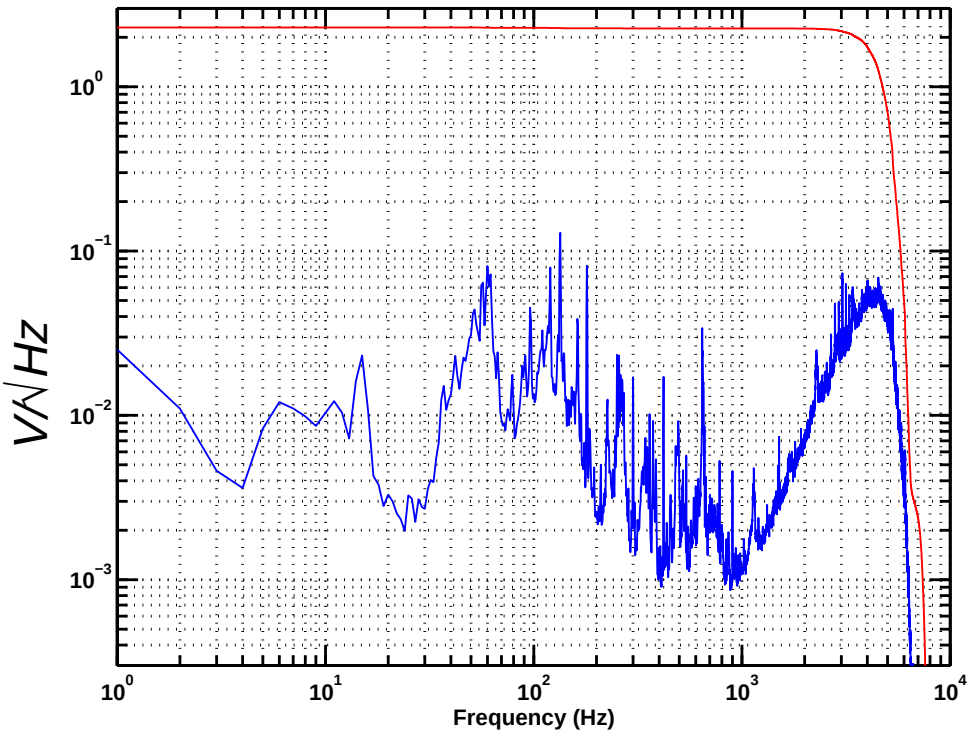
Spectra of error & control signals



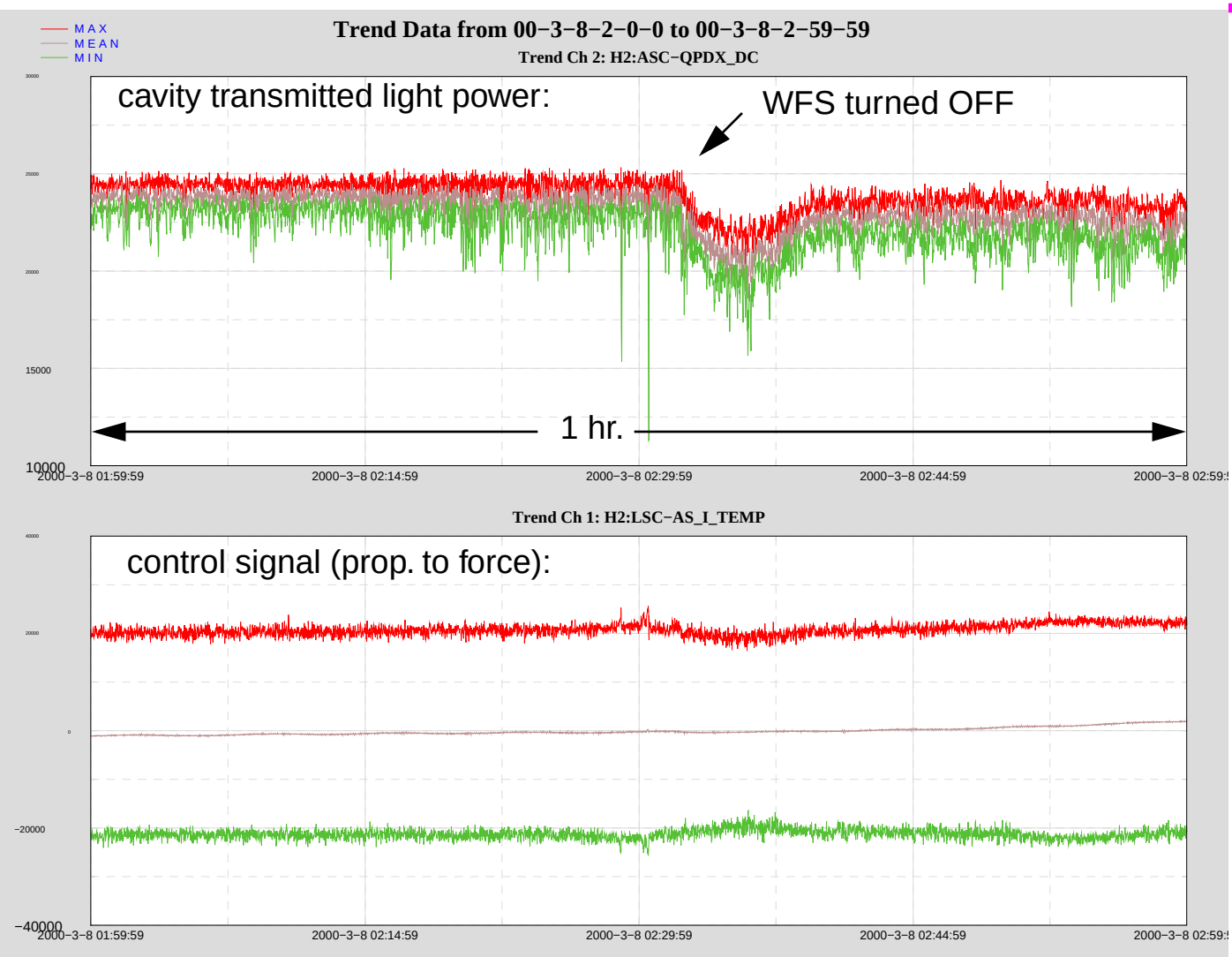
Error signal, converted to frequency units

red = rms vs. f



Length control signal, 0.4 mN/V

WFS alignment



- Digital filtering
  - 1/f overall loop response
  - low bandwidth, for now, u.g.f. < 1 Hz

WFS matrix

- All four TM orientation d.o.f. are modulated through a digital interface
- FFT of each WFS signal (each quadrant, if desired) taken to establish response