E2 Calibration of the Hanford 2km IFO

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calibration procedure

- idea: apply known force to a mass and measure displacement
- methods: swept sine, fixed frequency calibration lines, photon calibrator
- how good? Assume 1-10 events with SNR 10-100, the physical results should not be limited by the systematic uncertainties of the calibration
- +/- 1% amplitude, +/-10 microseconds

Sigg, D. LIGO-T970101-A-D

Allen, B. LIGO-T960189-00-E

hubble constant

- Determine the Hubble constant H_o
- require 3-4 interferometers
- amplitude accuracy required: 3%, timing accuracy required:1% of max timing range (-22 to +22 milliseconds)
- three detectors: 3 amplitudes and 2 time delays yields arrival directions (2), polarization amplitudes (2), and phase lag (1).
- four detectors: error box of 6^ox6^o degrees: search box for galaxy to get source redshift
- ten events out to 100 Mpc determines H_o to a few percent

Shutz, B.F., Nature 323 (1986) 310

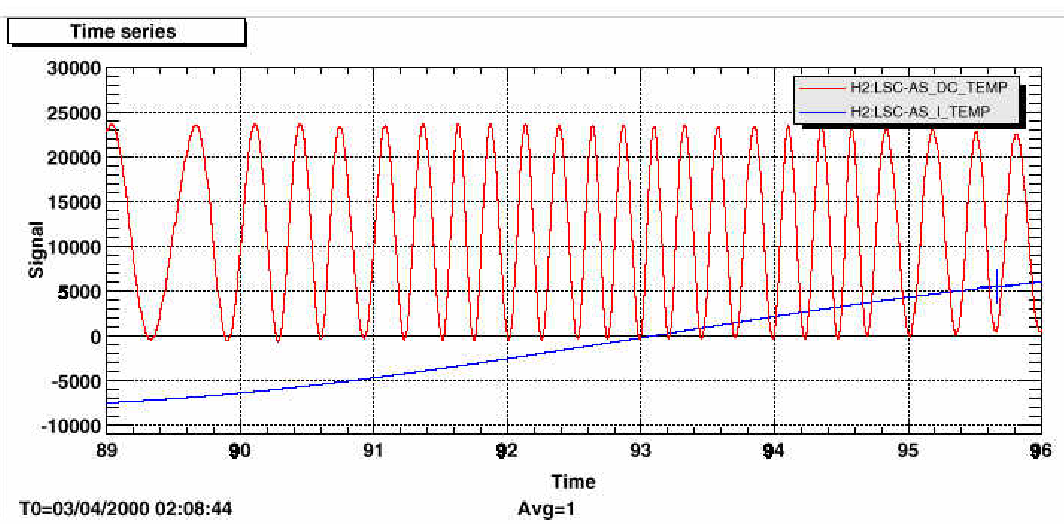
itm calibration

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

ITMx = 3.6 +/- 0.2 nm/count

ITMy = 3.5 +/- 0.2 nm/count



etm calibration

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

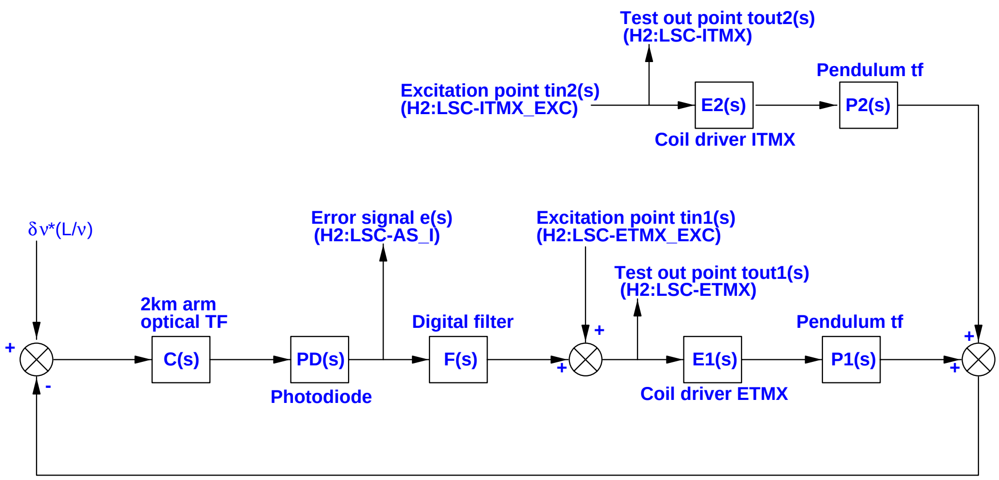
Assuming identical coil drivers (E1=E2) and pendulum transfer functions (P1=P2), and using equal excitations on both masses,

$$\alpha_{\mathrm{etm}} = \frac{E_{\mathrm{etm}}}{E_{\mathrm{itm}}} \alpha_{\mathrm{itm}}$$

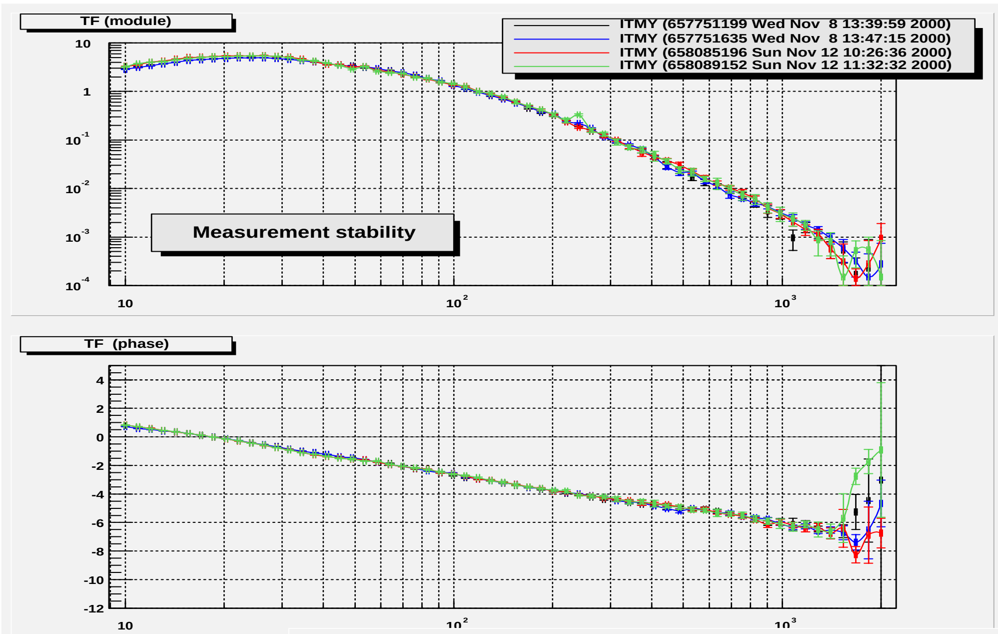
Calibrations for the ETM's are then

ETMx = 2.3 nm/count

ETMy = 2.0 nm/count

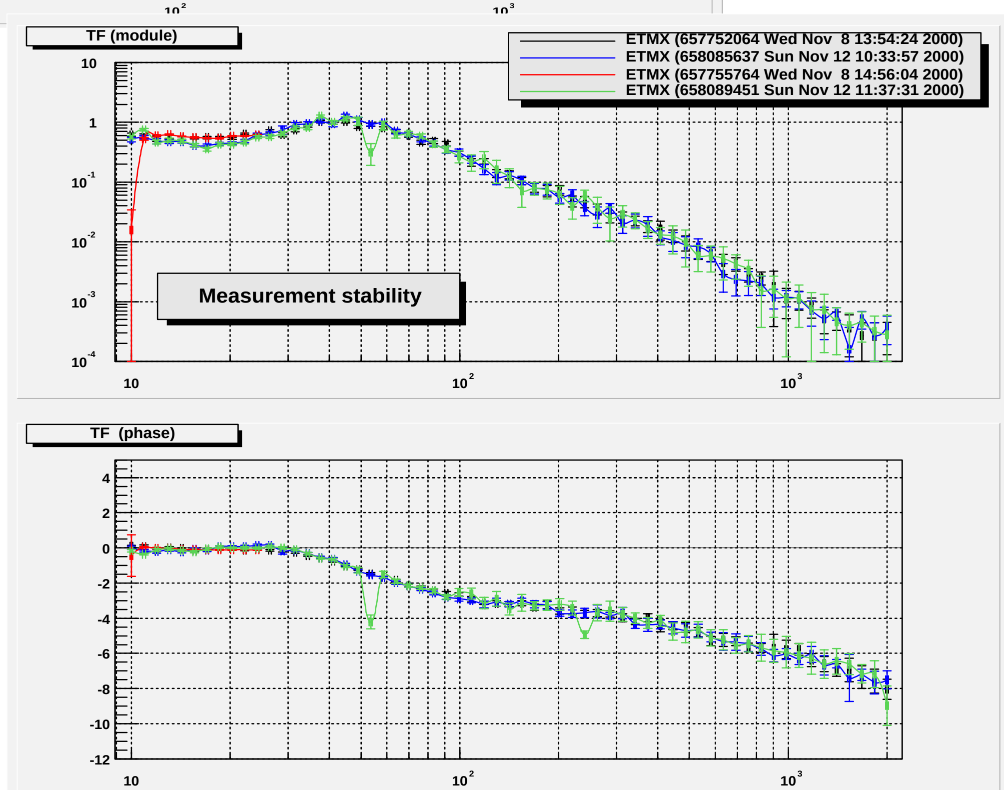


measurement stability



Meas. Stability

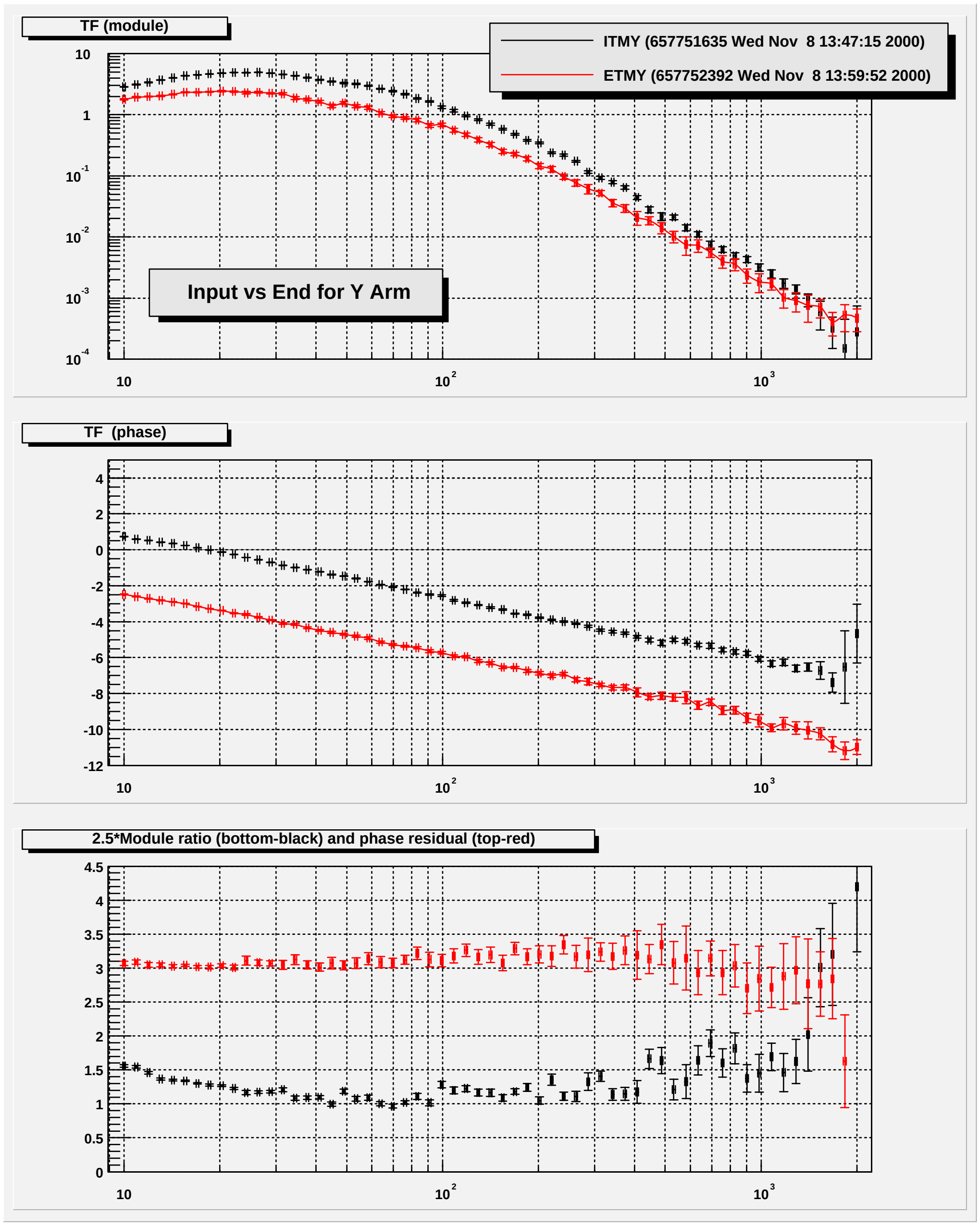
- Stable same day
- Differences @ low freq., up to 30% at 15Hz



X arm vs. Y arm

- Significant differences at low frequency

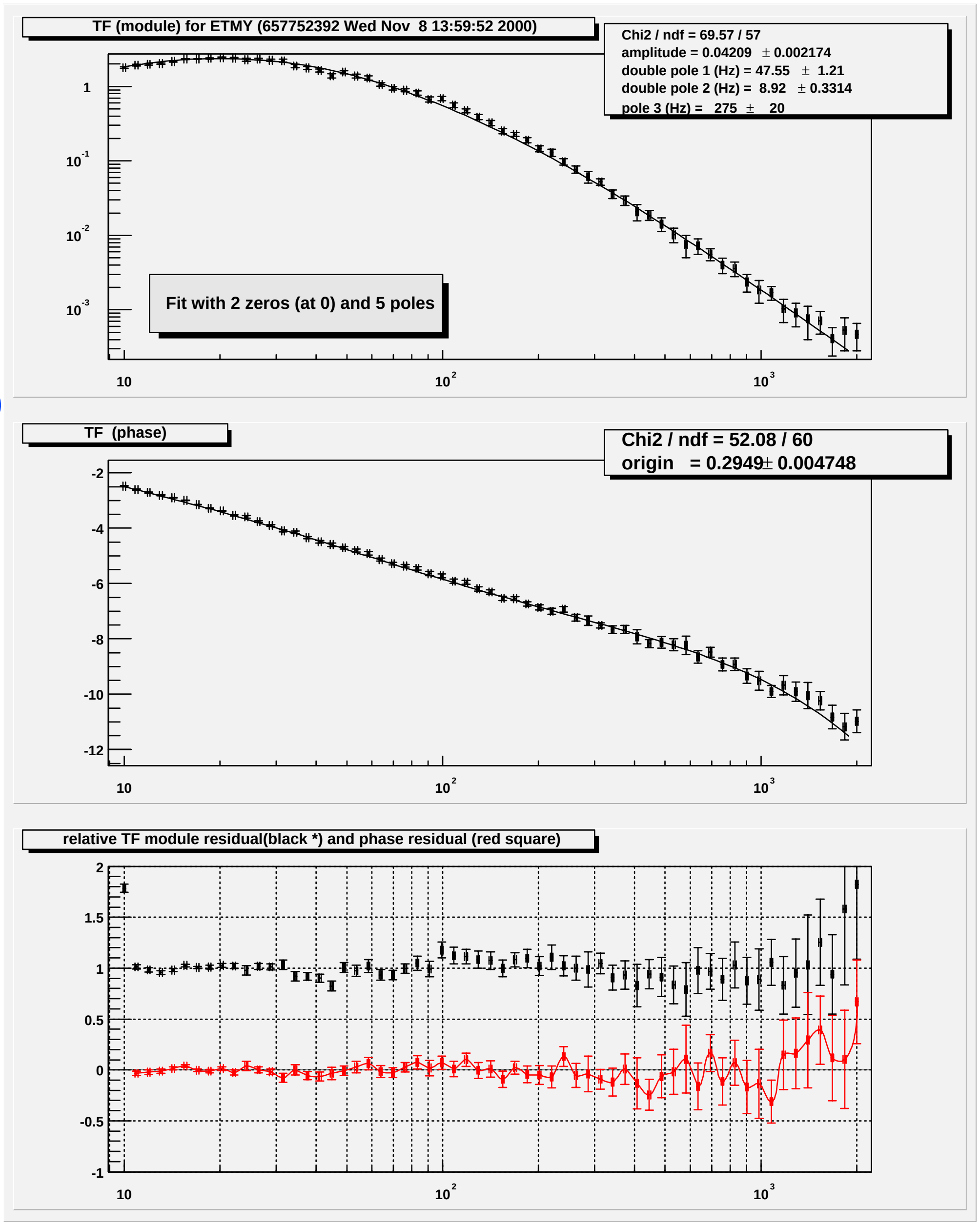
itm vs etm



TF (module)
ITMY (657751635 Wed Nov 8 13:47:15 2000)
ETMY (657752392 Wed Nov 8 13:59:52 2000)
Input vs End for Y Arm
TF (phase)
2.5*Module ratio (bottom-black) and phase residual (top-red)

fit to etm$_y$ transfer function

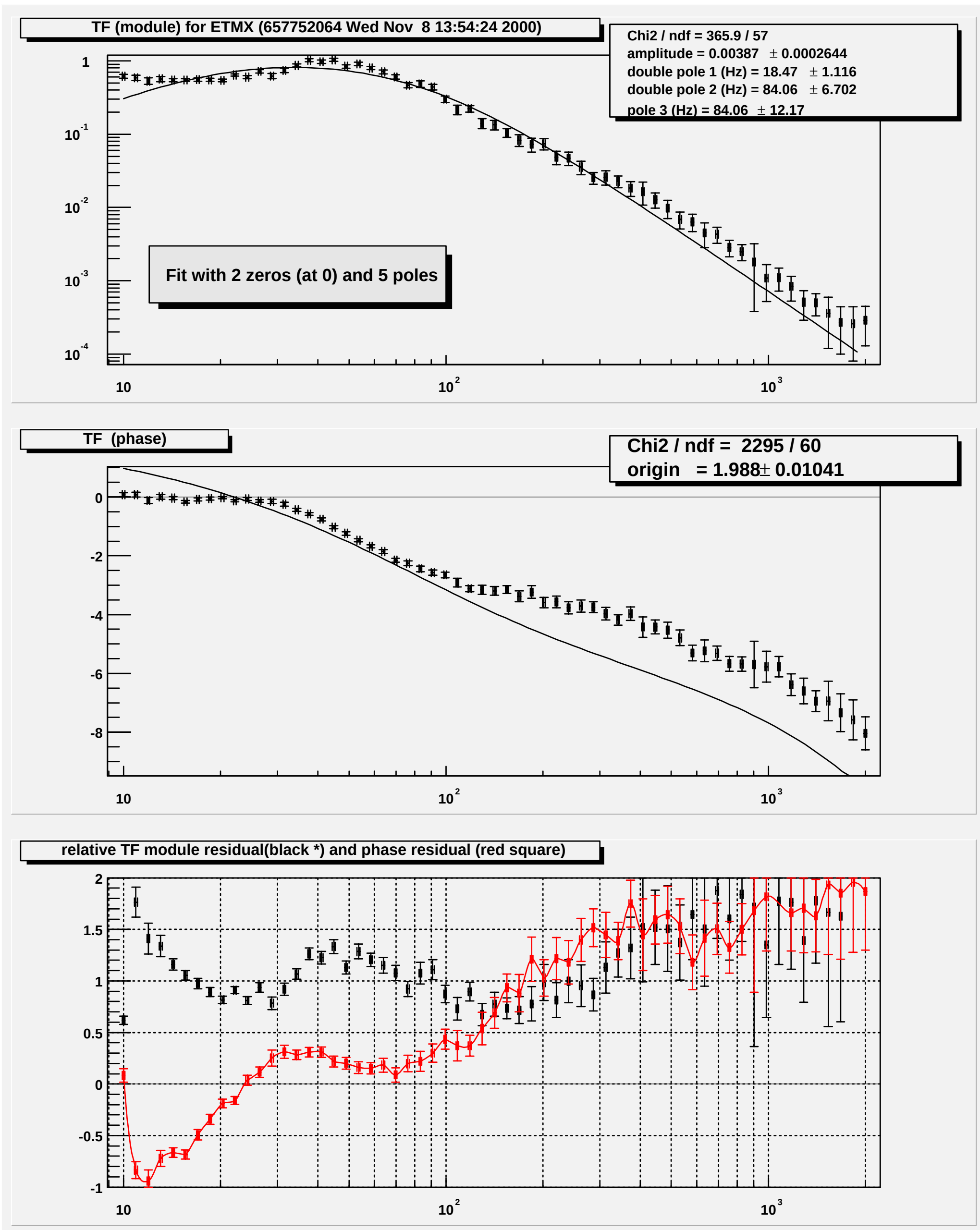
[fit](#)
- 2 zeros at 0Hz
- 5 poles (2 single, 1 double)



Y arm well represented

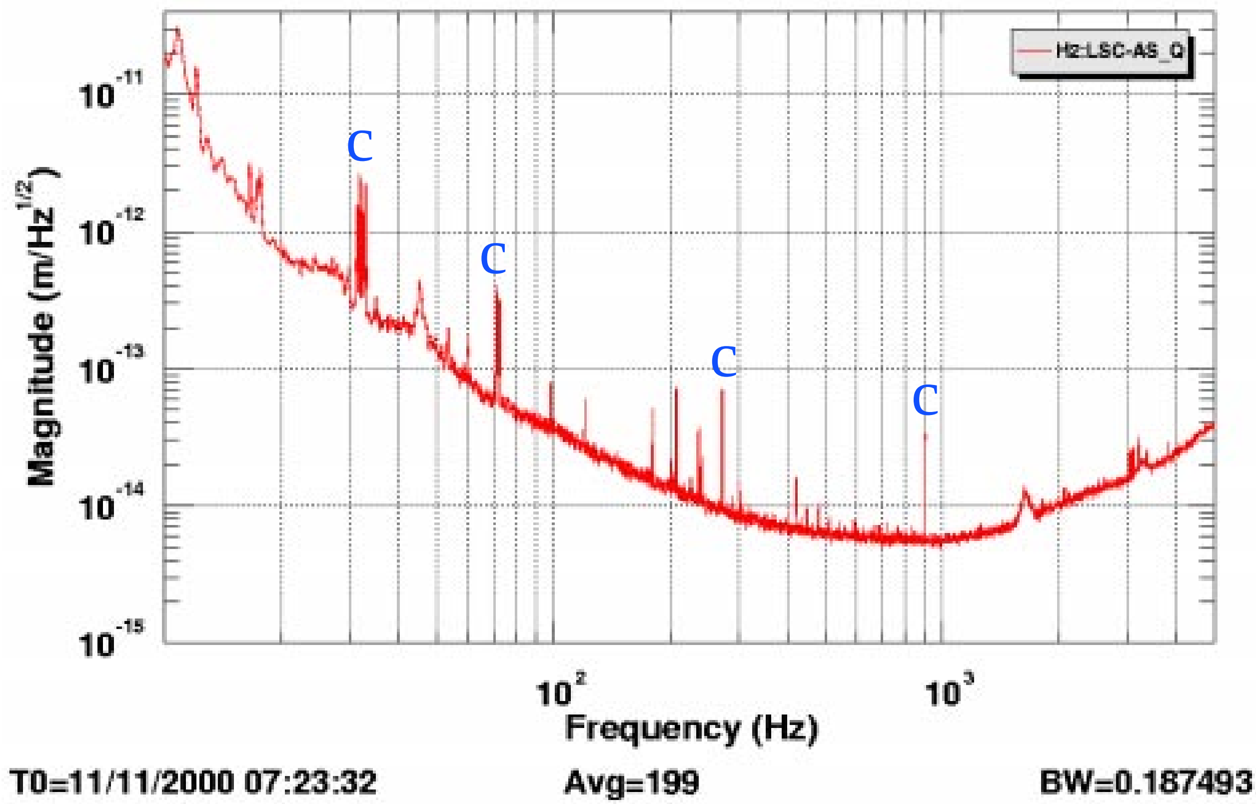
[LSC servo](#)
- 2 zeros at ~0Hz
- At high freq., should see mechanical TF and cavity response

fit to etm$_x$ transfer function



X arm complicated

sensitivity



- Scale set by absolute calibration
- Shape set by parametrization
- Visible calibration lines (“c”)
- 30% calibration accuracy