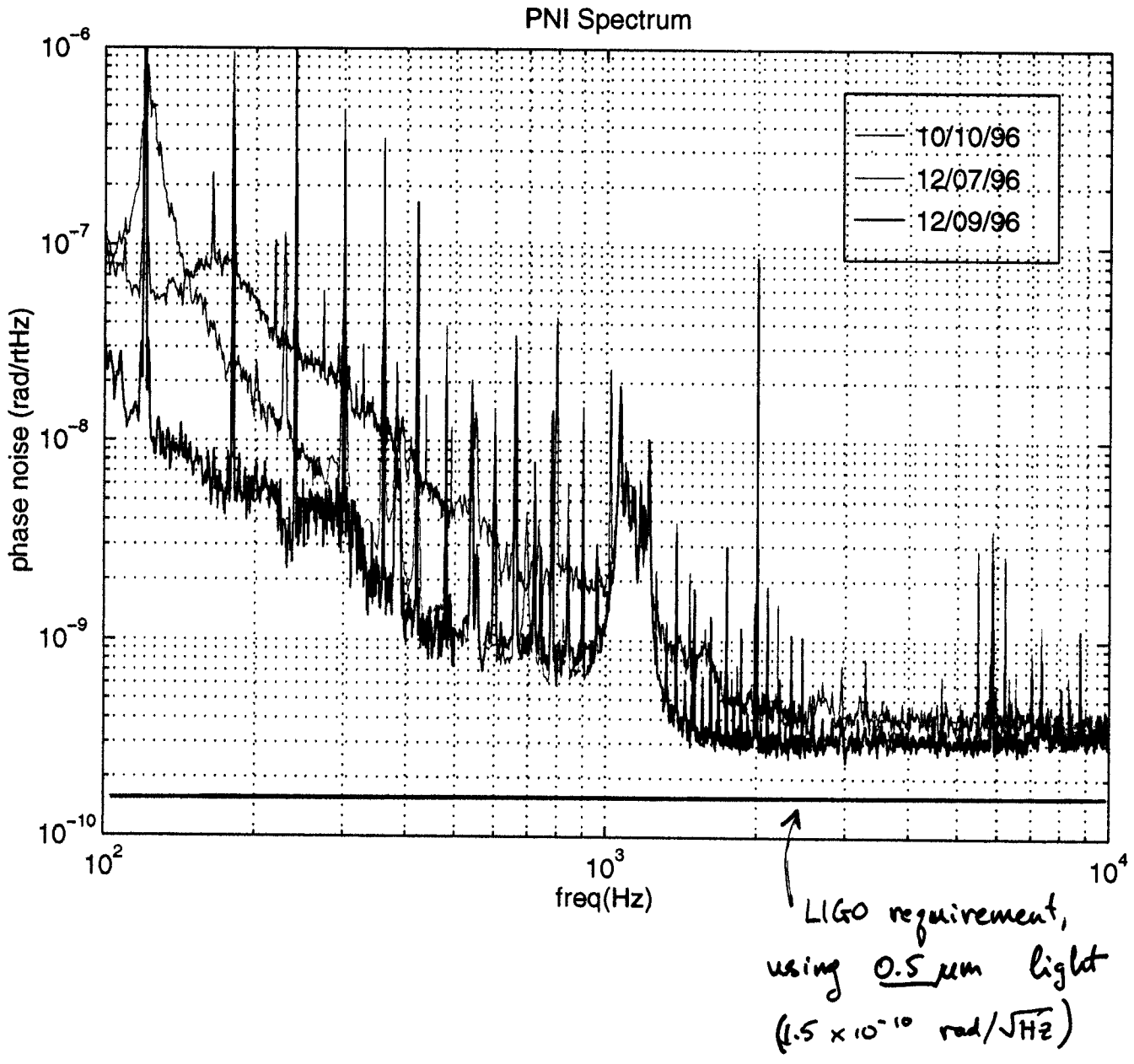
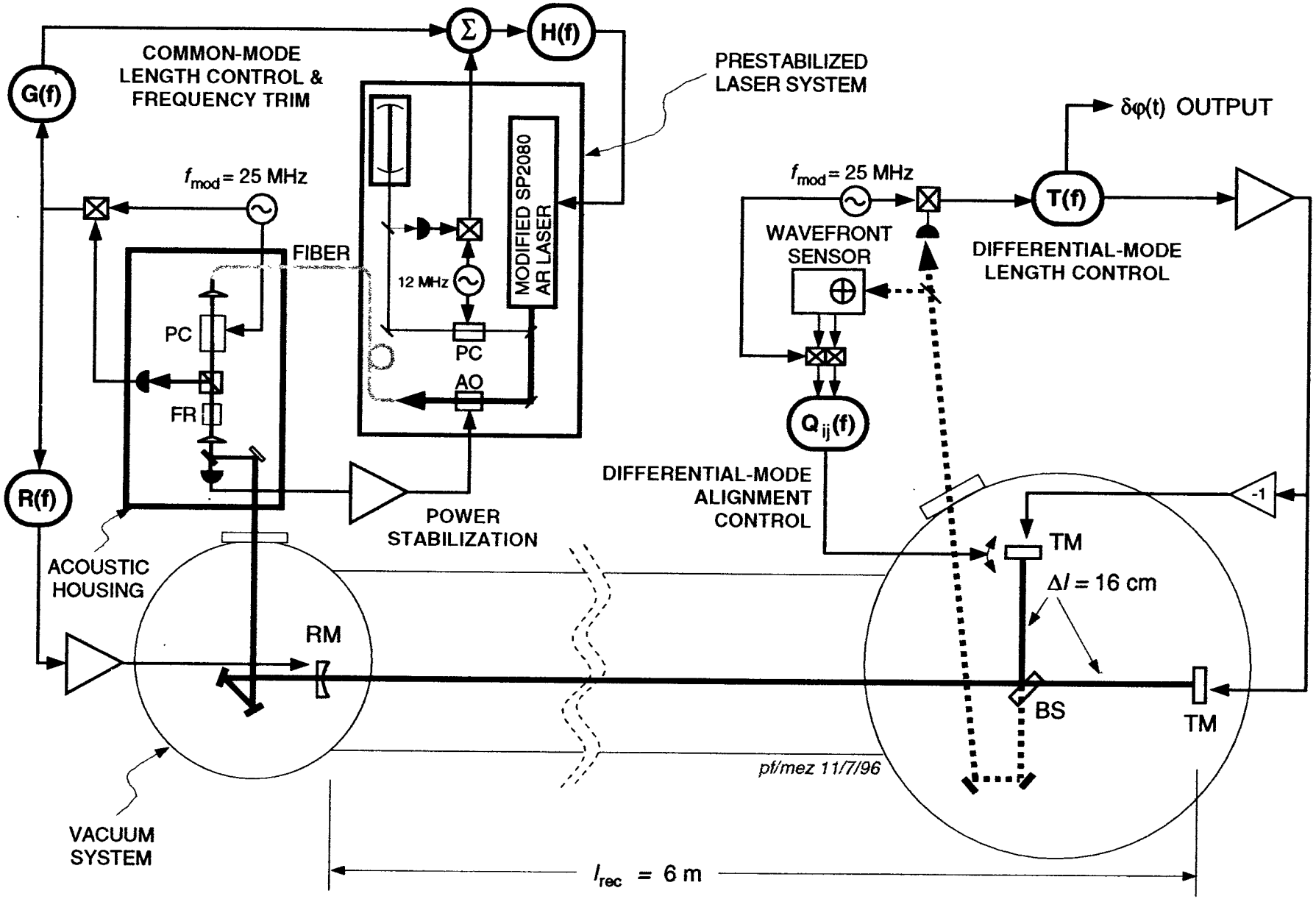
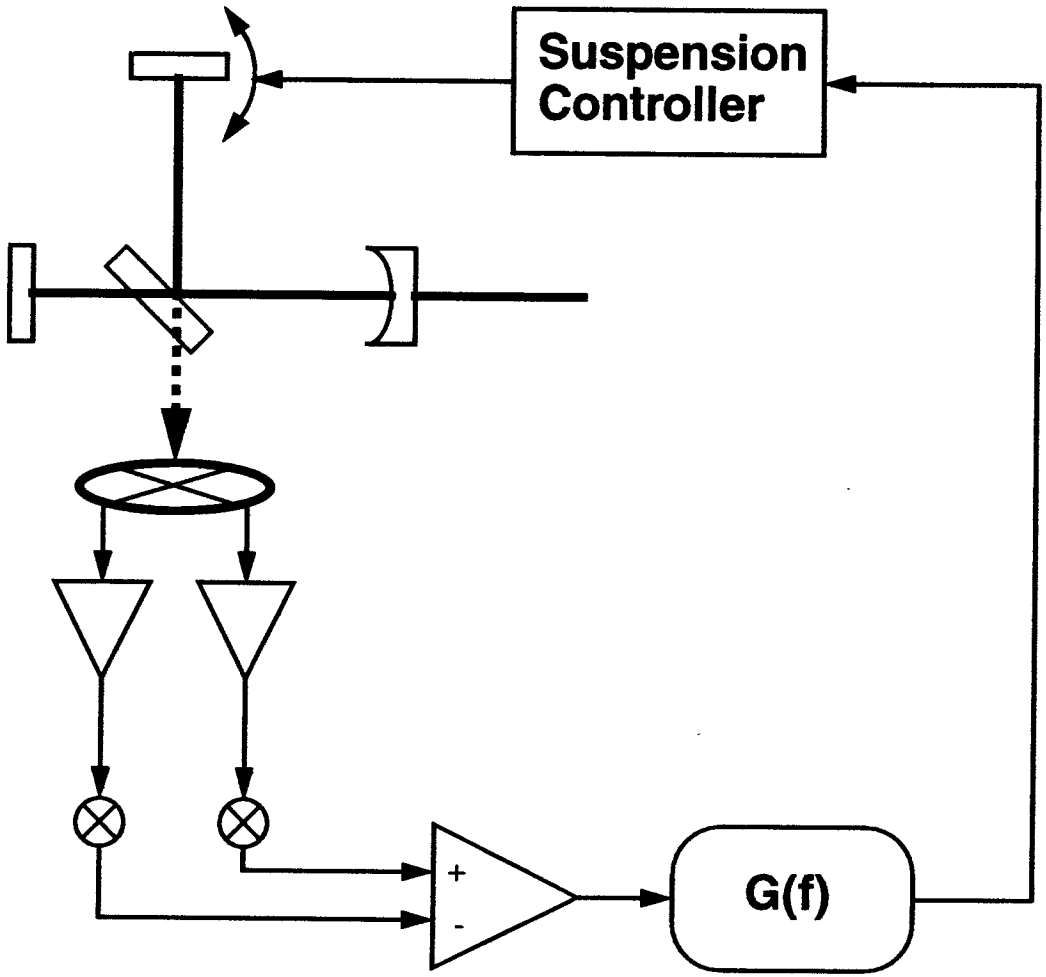
PNI Update
P. Fritschel
12 December 96



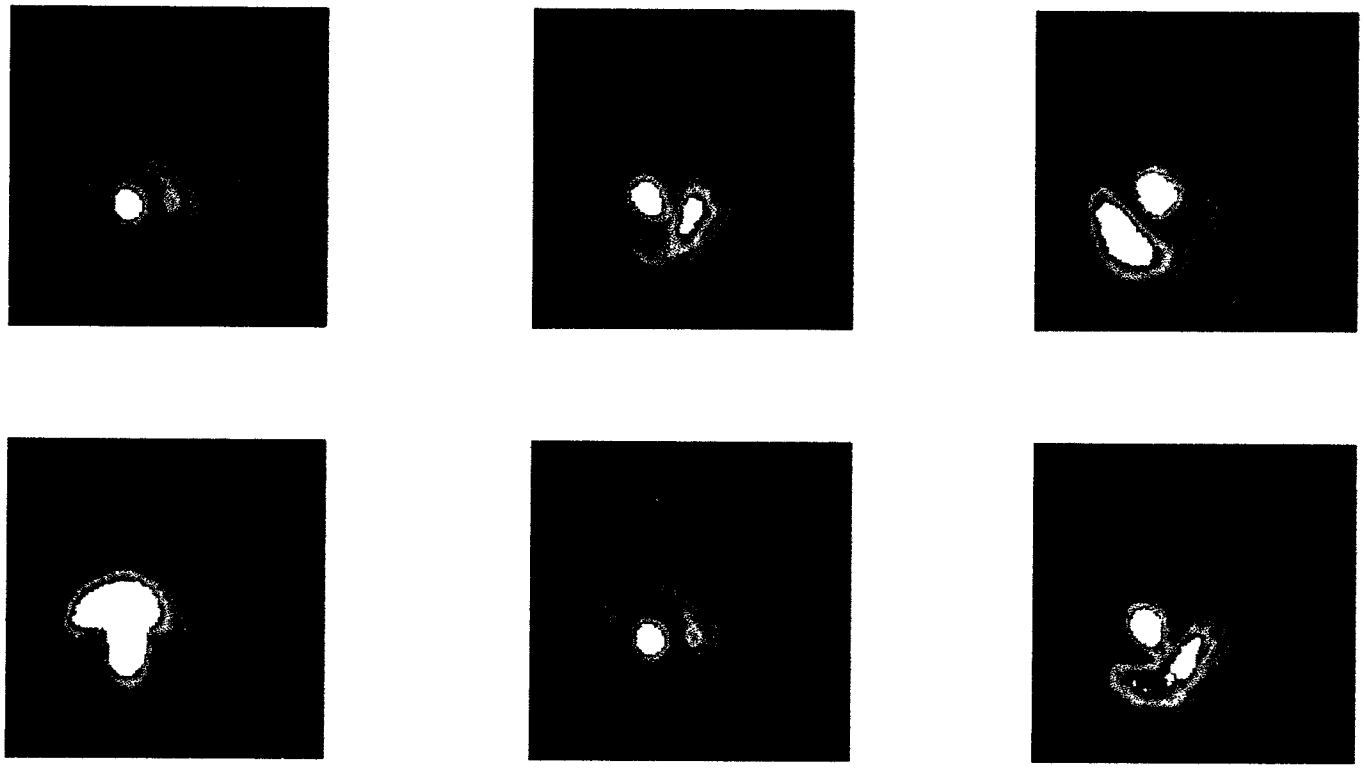
LIGO PHASE NOISE INTERFEROMETER



PNI Wavefront Alignment System

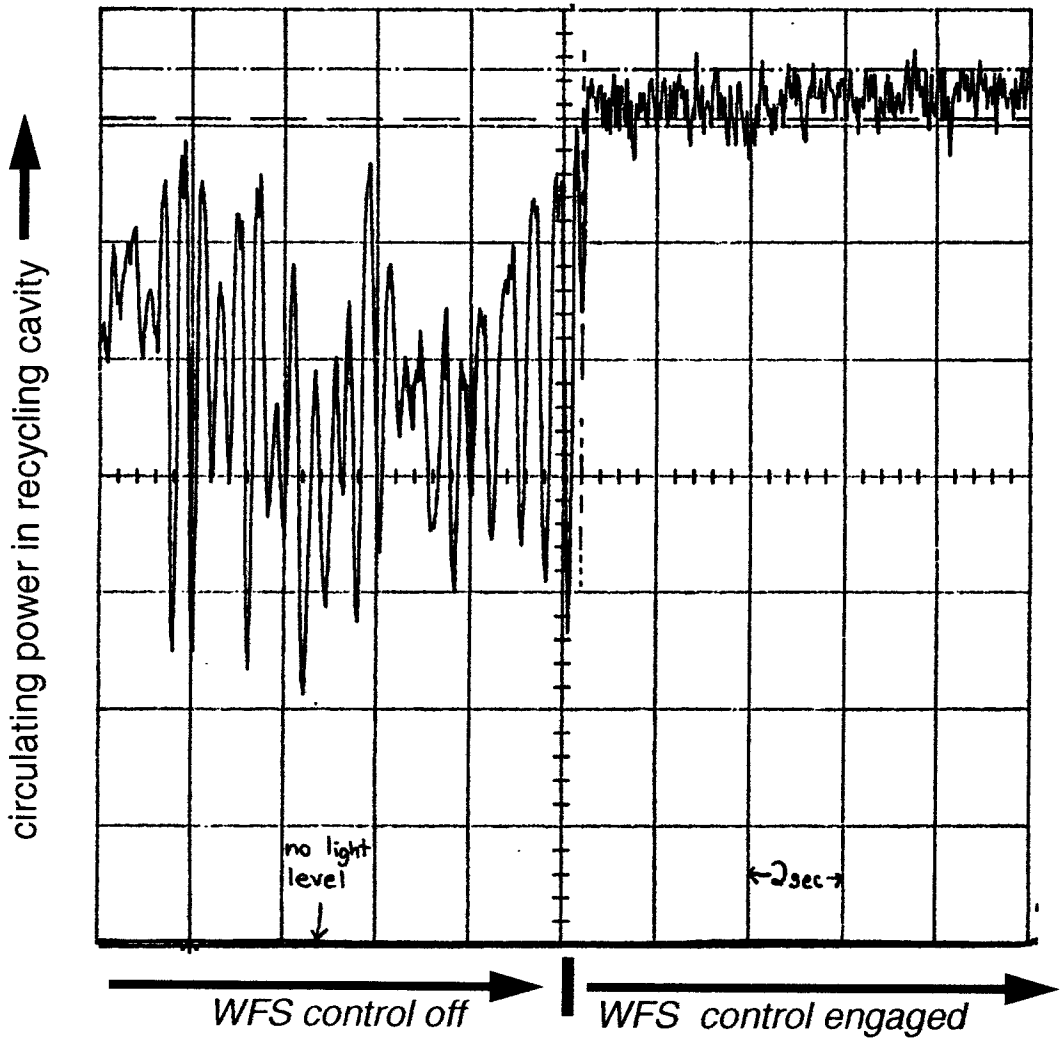


PNI Dark Port Images



May 17 1996, before WFS control installed

WFS Control Action



2 D.O.F. WFS control of PNI differential Michelson alignment;

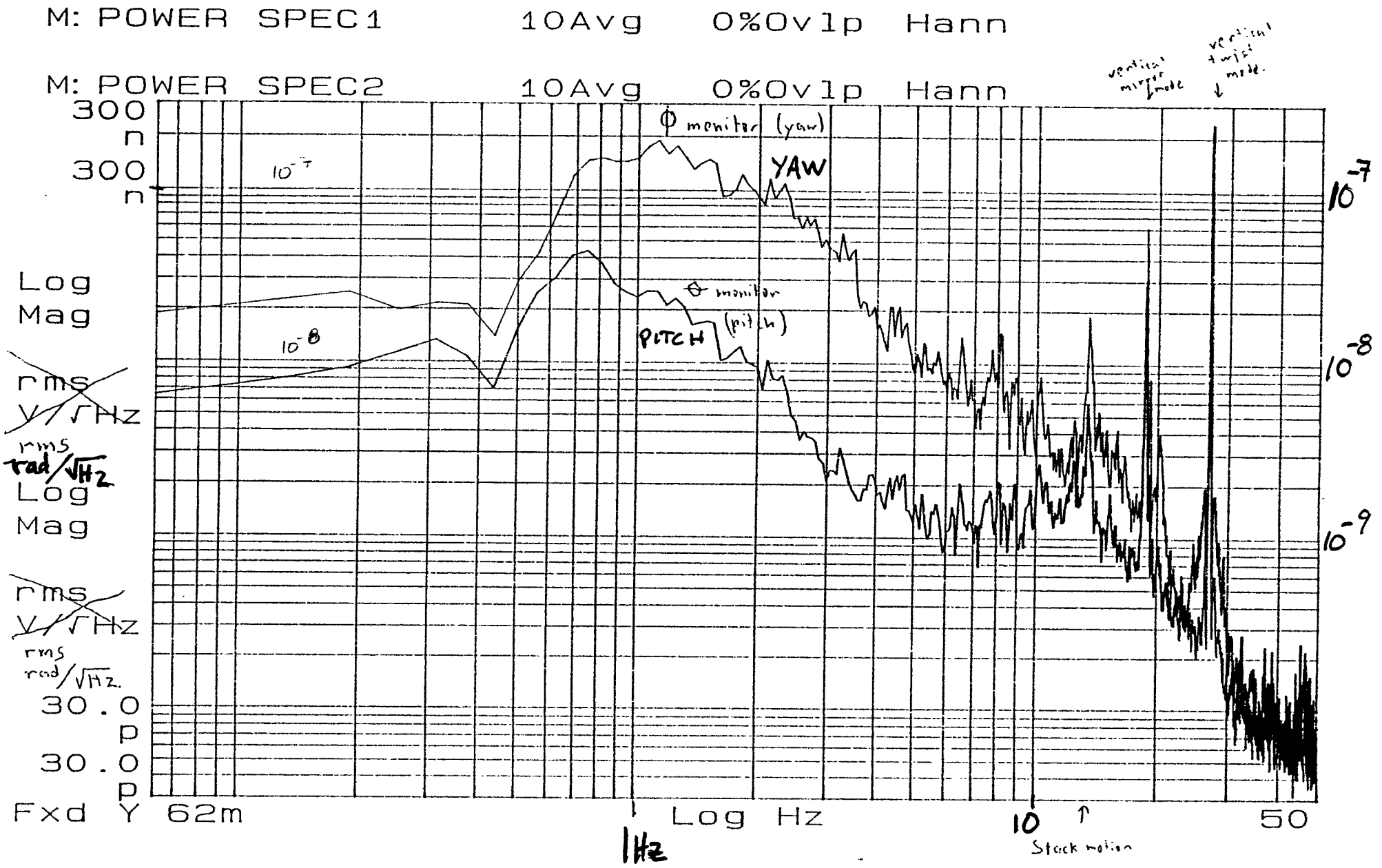
f_{ug} ~ 7 Hz,

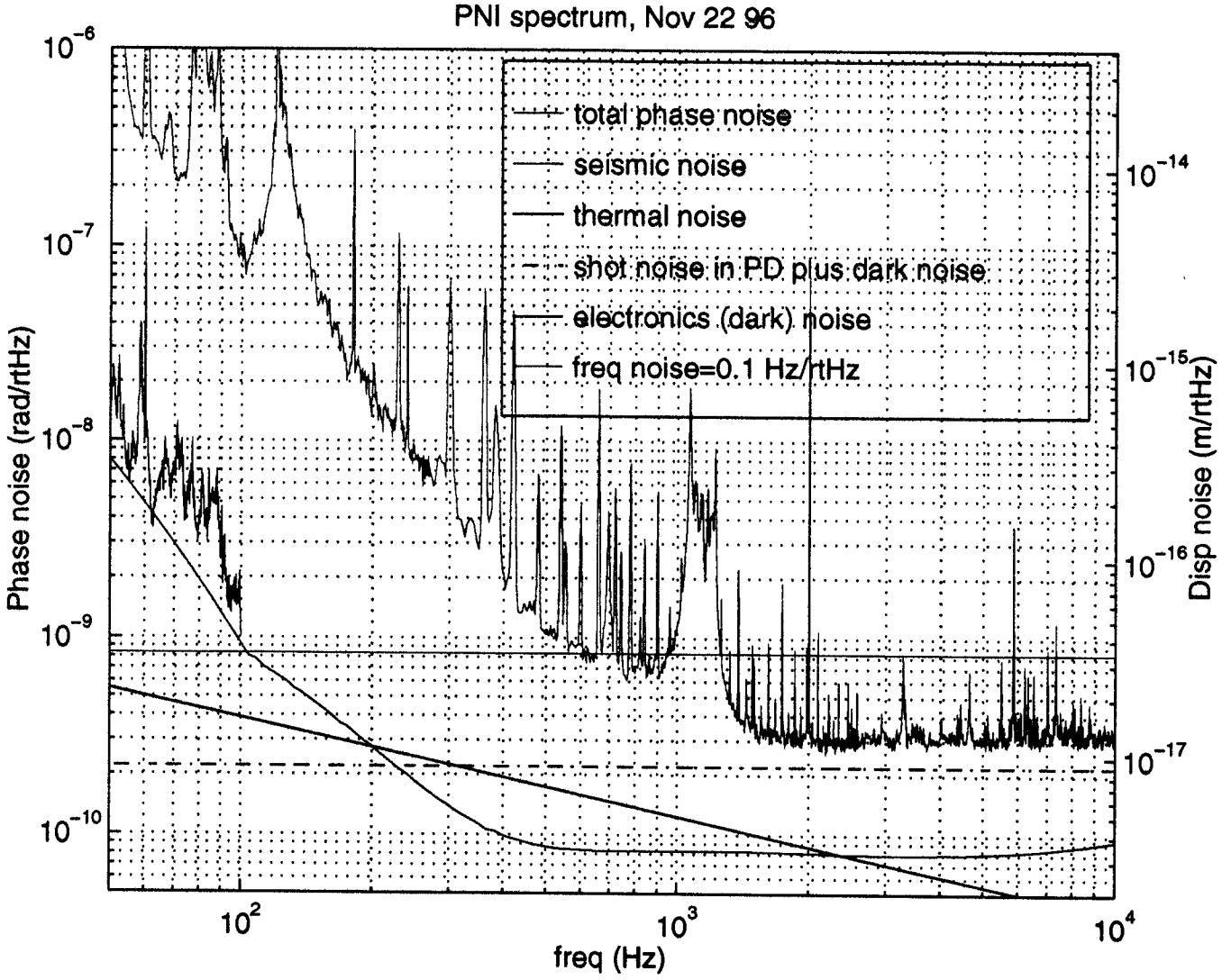
G(2 Hz) ~ 20 dB

Residual angle fluctuations

Wave front Sensor angle monitors - of M1 differential d.o.f.

6:30pm Friday 11/15/96




PNI spectrum, Nov 22 96
total phase noise
seismic noise
thermal noise
shot noise in PD plus dark noise
electronics (dark) noise
freq noise=0.1 Hz/rtHz
Phase noise (rad/rtHz)
Disp noise (m/rtHz)
freq (Hz)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-14
10^-15
10^-16
10^-17
10^2
10^3
10^4

Q:

PN1: Is it shot-noise limited ?

☐ Light-bulb test:

— apply same DC photocurrent with light bulb (sans IFO)

compare noise density at readout with noise with IFO

— $\frac{\tilde{V}_{IFO}(f)}{V_{l.b.}(f)} \approx 1.3$

☐ Non-stationary effect.

- Increase over stationary noise:

$$\sqrt{\frac{P_{AS}^{c}}{P_{AS}^{T}} + \frac{3}{2}\frac{P_{AS}^{sb}}{P_{AS}^{T}}} \Rightarrow \underbrace{1 - 1.25}_{\text{can measure } P_{AS}^{c}/P_{AS}^{sb} \text{ using an OSA to get this}}$$

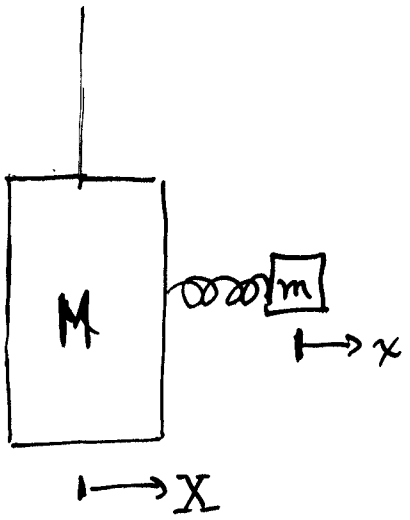
☐ Signal sensitivity:

— measurements of carrier / sidebands power levels, recycling gain, photodetector gain, ...

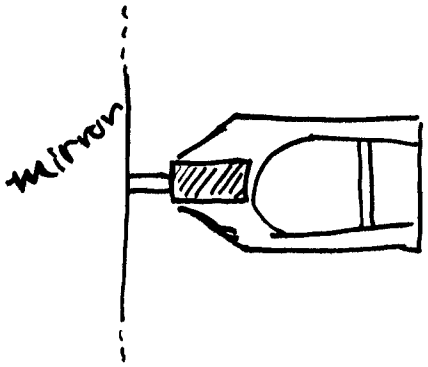
show that the measured sensitivity (amps / radian) agrees with calculation.

A: Not quite shot-noise limited, but very close (10-20%)

Thermal Noise in magnet/standoff/fin assemblies



$$\left|x_m^2\right|_{f_0} \simeq \frac{4k_B T Q}{m\omega_0^3}$$



- measured Qs: ~ 150-200
- $m \sim \frac{1}{2}$ gm
- $\omega_0 \sim 2\pi \times 1$ kHz

$$x_m(f_0) \simeq 1.5 \times 10^{-13}\ m/\sqrt{Hz}$$

Recoil of mirror:

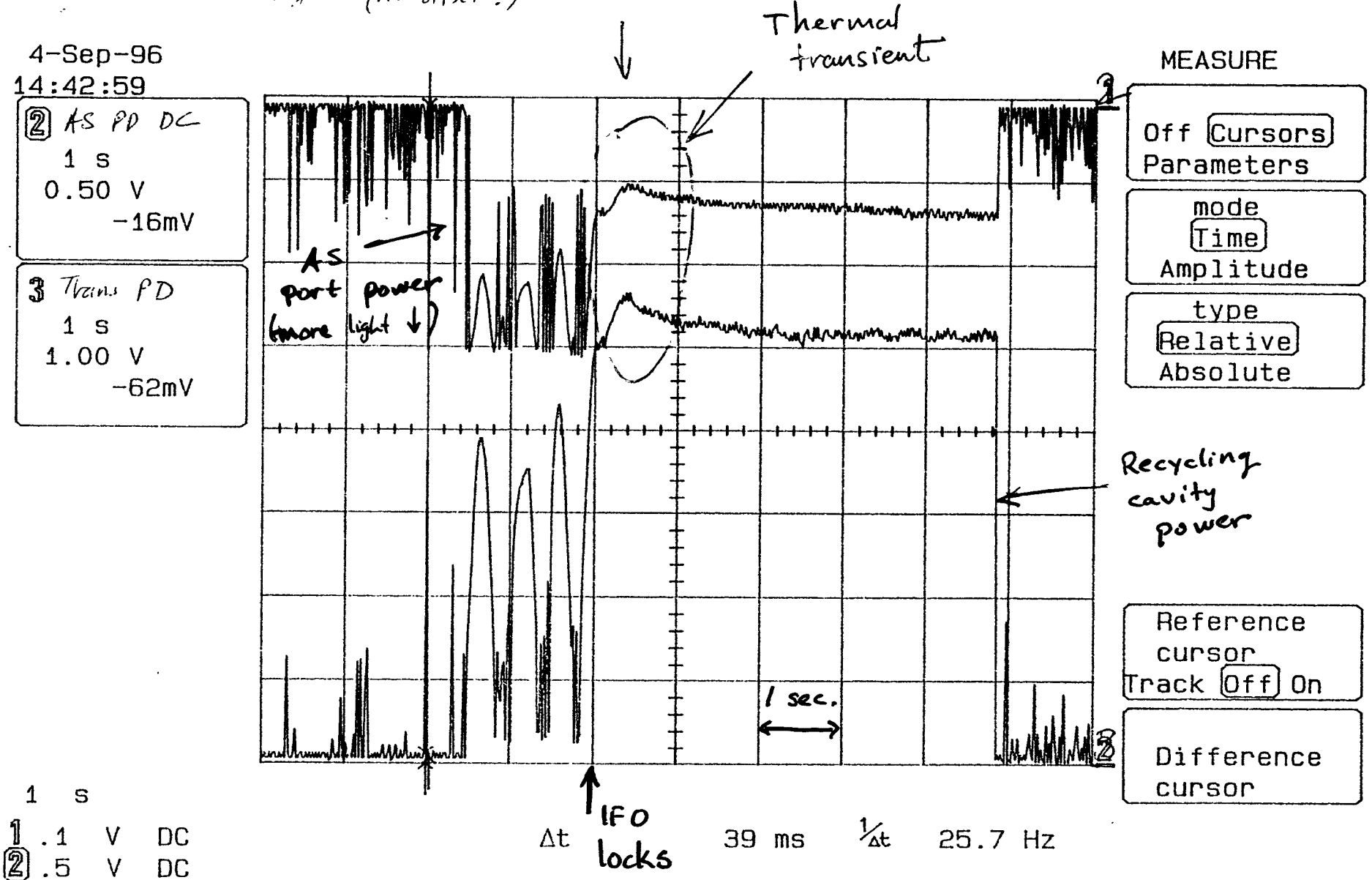
$$X_M(f) \simeq x_m \times \frac{m}{M} = \frac{0.5}{250} \times 1.5 \times 10^{-13}$$

$$\simeq 3 \times 10^{-16}\ m/\sqrt{Hz}$$

- Below - resonance thermal noise is predicted to be below - but not too far below - current spectrum.

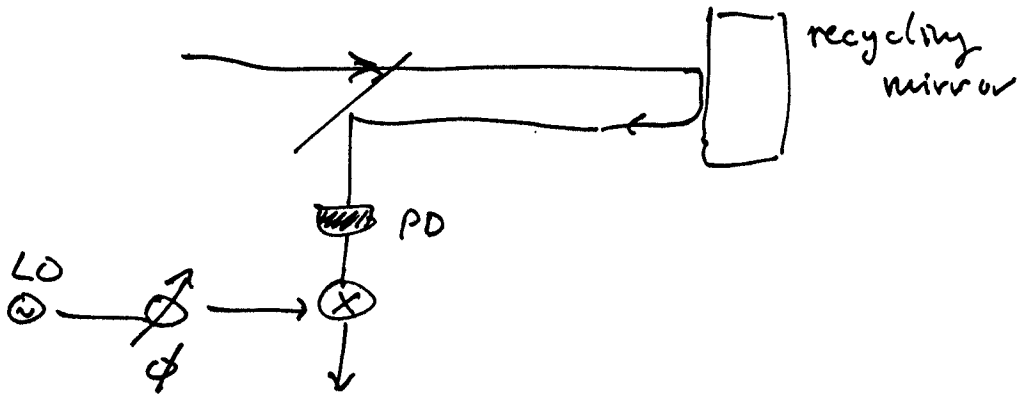
During acquisition, there is a point where the AS DC is lower, & the Rec cav power is higher (MI offset ?)

4 Sept 96



Mysteries:

- MI noise very dependent on demodulator phases –
  - both differential & common mode signals –
  - 'optimal' common mode ϕ changes from day-to-day ($\sim 10°$)
  - current 'optimal' common mode ϕ is nearly 90° to phase which is maximally sensitive to δf_{laser}



- Lesson: very useful to look at both I & Q phases of all signals.

FUTURE PLANS

- [ ] Wrap-up Ar^+ laser studies
  - study demod. ϕ dependence
  - operate w/ higher input power

- [ ] Conversion to Nd:YAG -
  - beginning in January
  - laser characterization done
  - ref cavity, stabilization electronics from Caltech

- [ ] First Phase: linear cavity
  - measure prestab. frequency noise
  - develop servo control, using new AOM input
  - install 2 WFS + control

- [ ] Second Phase: recycled Michelson.
  - attempt to control parasitic interferometers
    - lots of isolators & Brewster angles
  - isolate laser table with STACIS to lower velocity
  - test high-power photodetector prototype
  - possible test of digital length control hardware/software