Science & Integration Meeting

Agenda

- Detector & R&D

→ ›› NPRO stabilization results (LIGO-G960244-00-D) Mason/Savage

›› Interferometer acquisition modeling results Sievers

›› FMI wavefront sensing results Mavalvala/Sigg

›› PNI status & plans Fritschel

›› 40m recycling status Logan/Spero

›› Core Optics Status: REO coating performance analysis Jungwirth

›› FFT modeling (20 min) Kells

›› DAQ prototype plan for 40m Bork/Barker

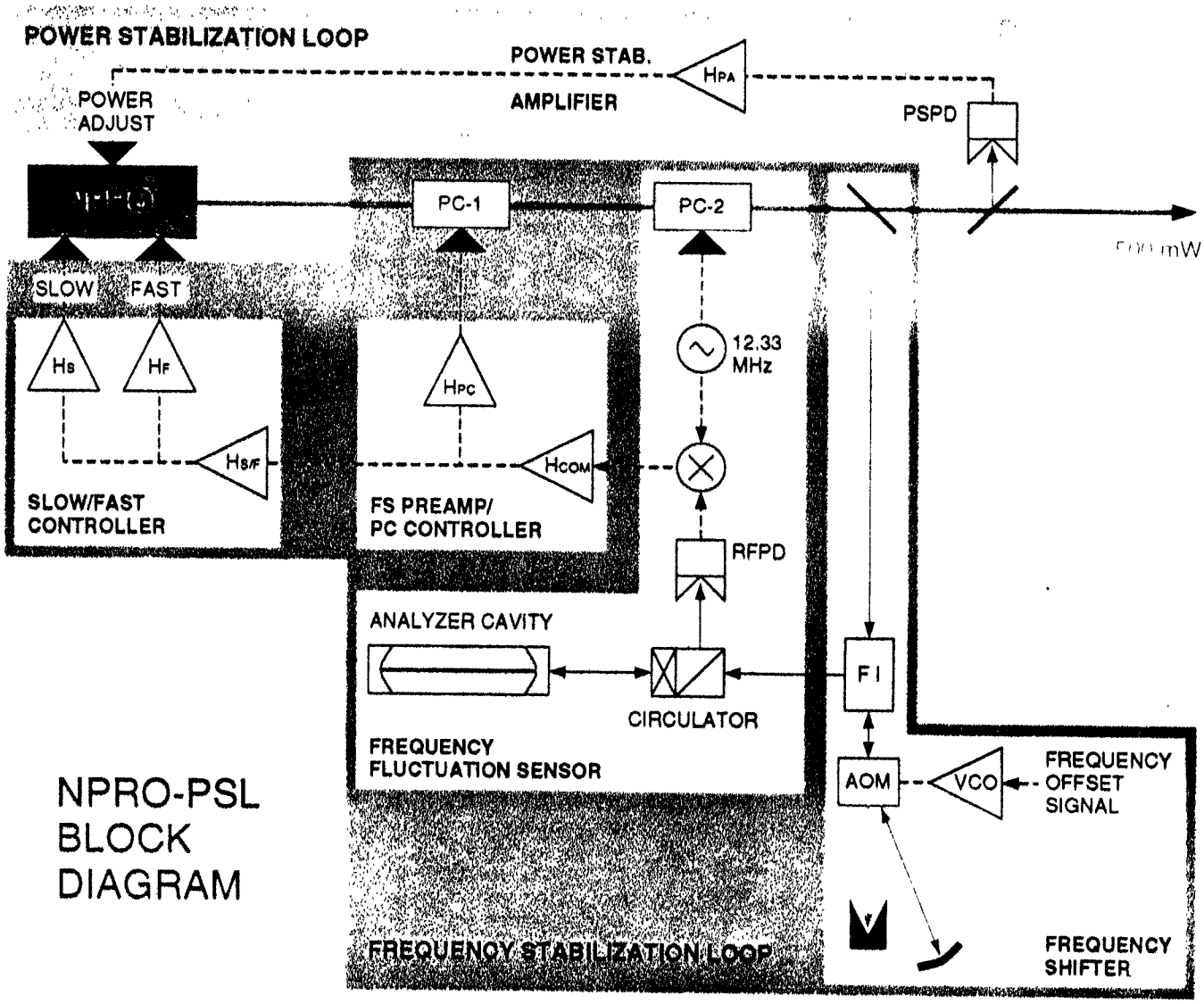
NPRO Stabilization Results

R. Abbott, A. Abramovici, A. Dominjon, J. Mason, R. Savage

NPRO-PSL Goals

- Test stabilization techniques on a Nd:YAG laser.
  - ›› Head start on LIGO IR-PSL (10 Watt Nd:YAG laser, Interim Design Review at Lightwave on 12/18/96)
  - ›› Feed conceptual design of IR-PSL (DRR 3/24/97)
- Deliver a low-power, stabilized Nd:YAG laser to MIT group for the PNI IR conversion - January 1997.
- *NPRO-PSL Design Requirements* - LIGO-T960082-00-D
  - ›› Relative power fluctuations < 1 x $10^{-8}/Hz^{1/2}$ above 100 Hz
  - ›› Frequency fluctuations < 10mHz/$Hz^{1/2}$ 100 Hz to 4 kHz
- *NPRO-PSL Conceptual Design* - LIGO-T960089-00-D

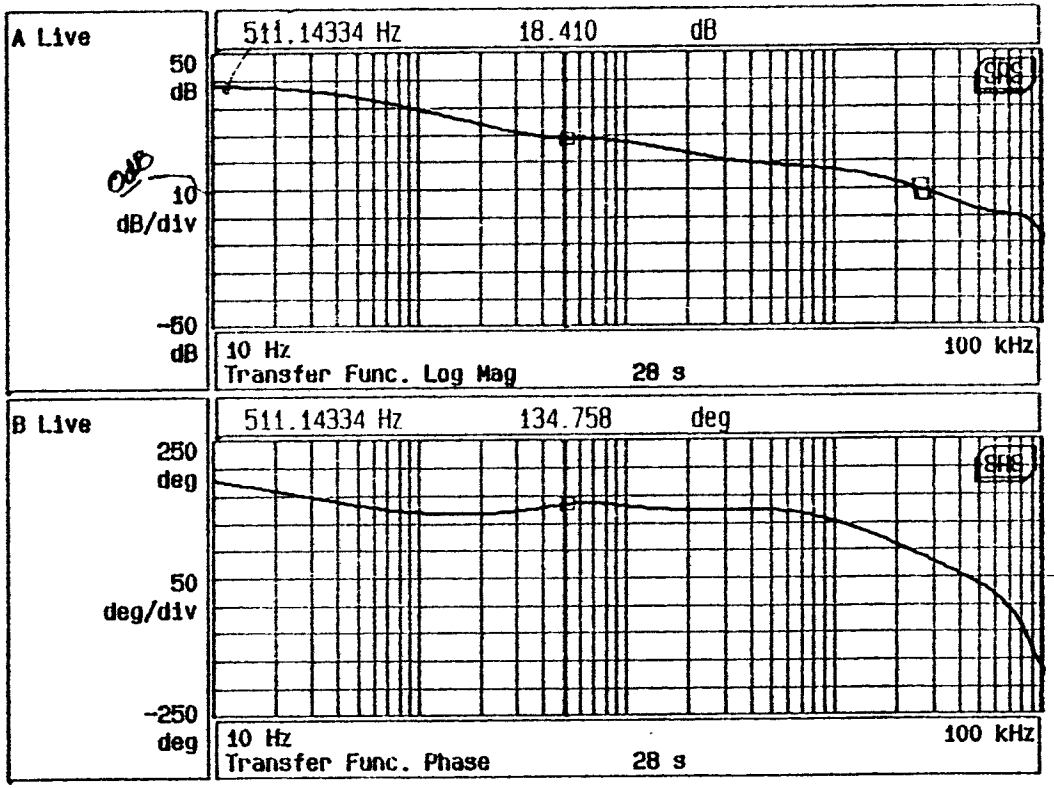
Nd:YAG Laser: NPRO Stabilization



NPRO-PSL BLOCK DIAGRAM

open loop transfer function

- Power stabilization loop transfer function - Source 100 mV pp
Gain on PSM 50 - with Capacitance on the 9V output of PSPD -
52 dB



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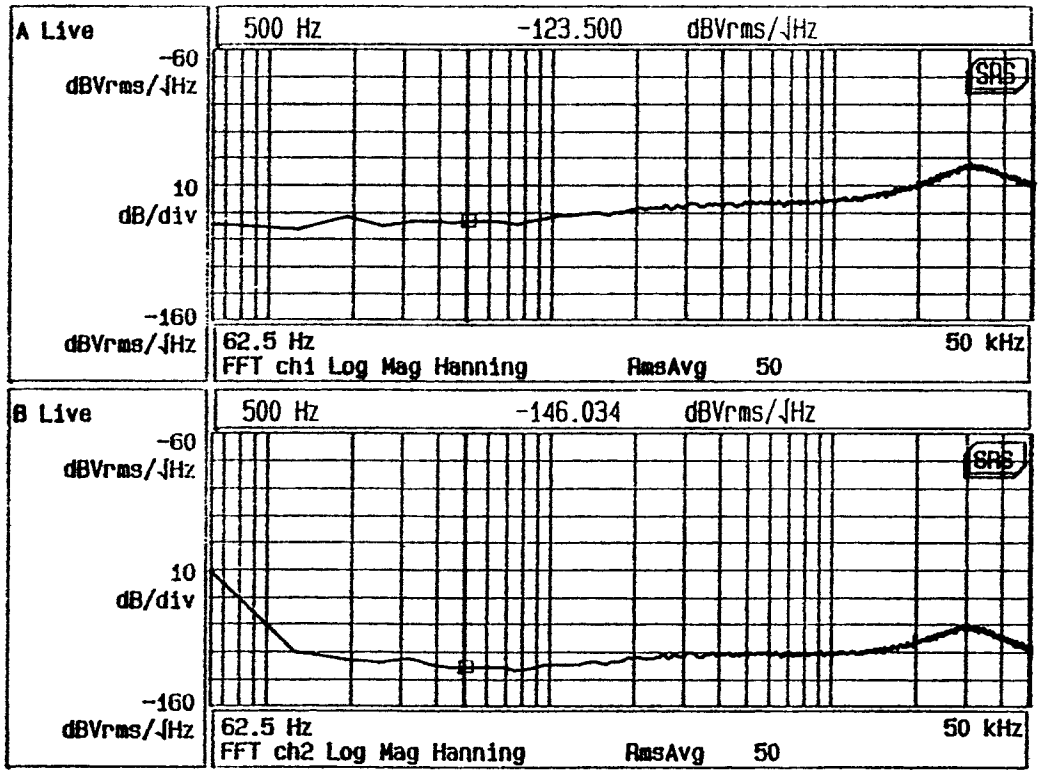
At 500Hz
gain = 12 dB
and we have seen 17 dB
of suppression outside the loop!

Closed loop
Same config. as
for 19:56 plot.

now seeing ~ 17dB suppression
outside the loop!



PSPD $V_{PSPD} = 20.5V$.

TL. $V_{TL} = 1.22V$

8/29/96 20:05:37

$\frac{\Delta P}{P}_{500Hz} \sim 4.1 \cdot 10^{-8}$ W/rms/W√Hz

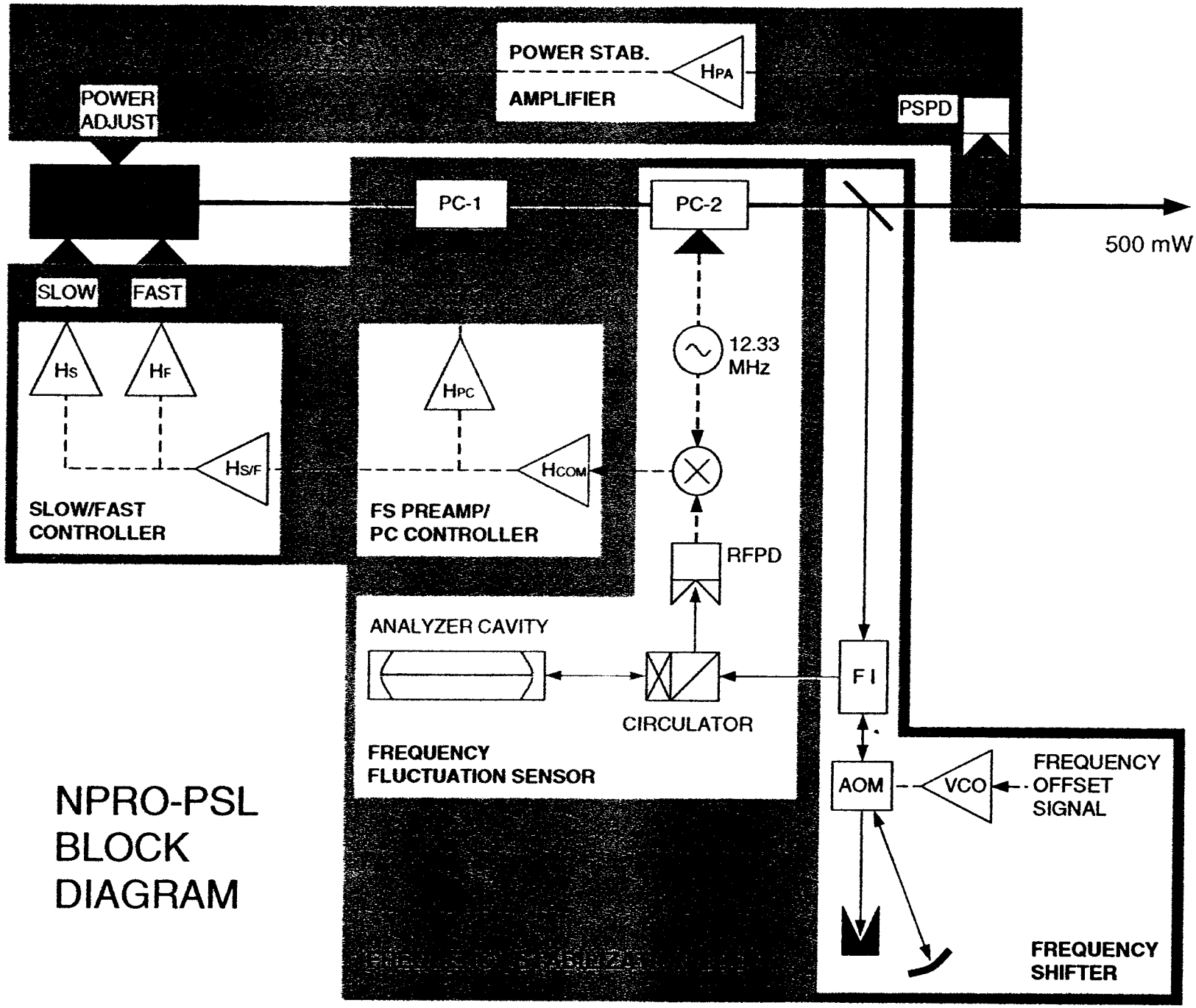
Frequency Stabilization for the NPRO Nd:YAG PSL

R. Abbott, J. Mason, R. Savage

- Demonstration of frequency stabilization using Lightwave Model 126 Nd:YAG NPRO laser
  - ›› Interim 1064 nm light source until 10W Nd:YAG developed
    - — To be incorporated into the PNI
    - — To be incorporated into the 40 m (depending on schedule)
  - ›› Model 126 to be used as master oscillator in 10 W MOPA under development
    - — Frequency stabilitization to be applied to master oscillator

A first pass at frequency stabilization

- In the beginning, there existed requirements
  - 1 mHz/rtHz from 100 Hz to 4 kHz
  - Fixed length reference cavity
- A first pass solution (A. Abramovici, R. Savage)
  - A scheme for frequency stabilization devised
  - Laser characterized
  - Servos designed and built
    - Slow/Fast loop controller built by CDS
    - Pockels cell controller to be existing LLSPA controller
- Testing (J. Mason, R. Savage)
  - Pockels cell left out to expedite testing of S/F controller
    - Modeling predicted lock possible with lower bandwidth
  - Difficulty encountered trying to lock up the fast loop

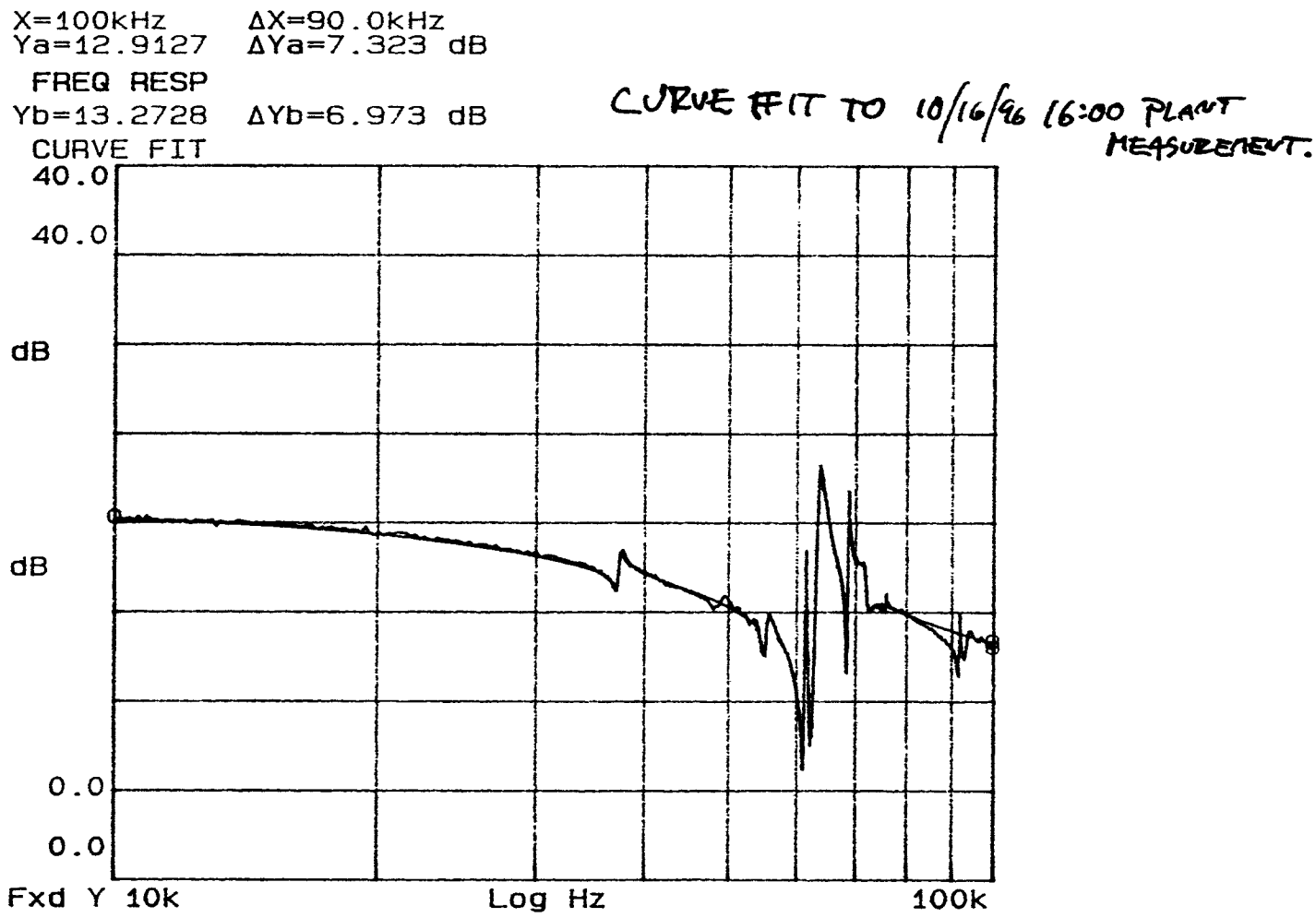


NPRO-PSL BLOCK DIAGRAM

A second pass at frequency stabilization

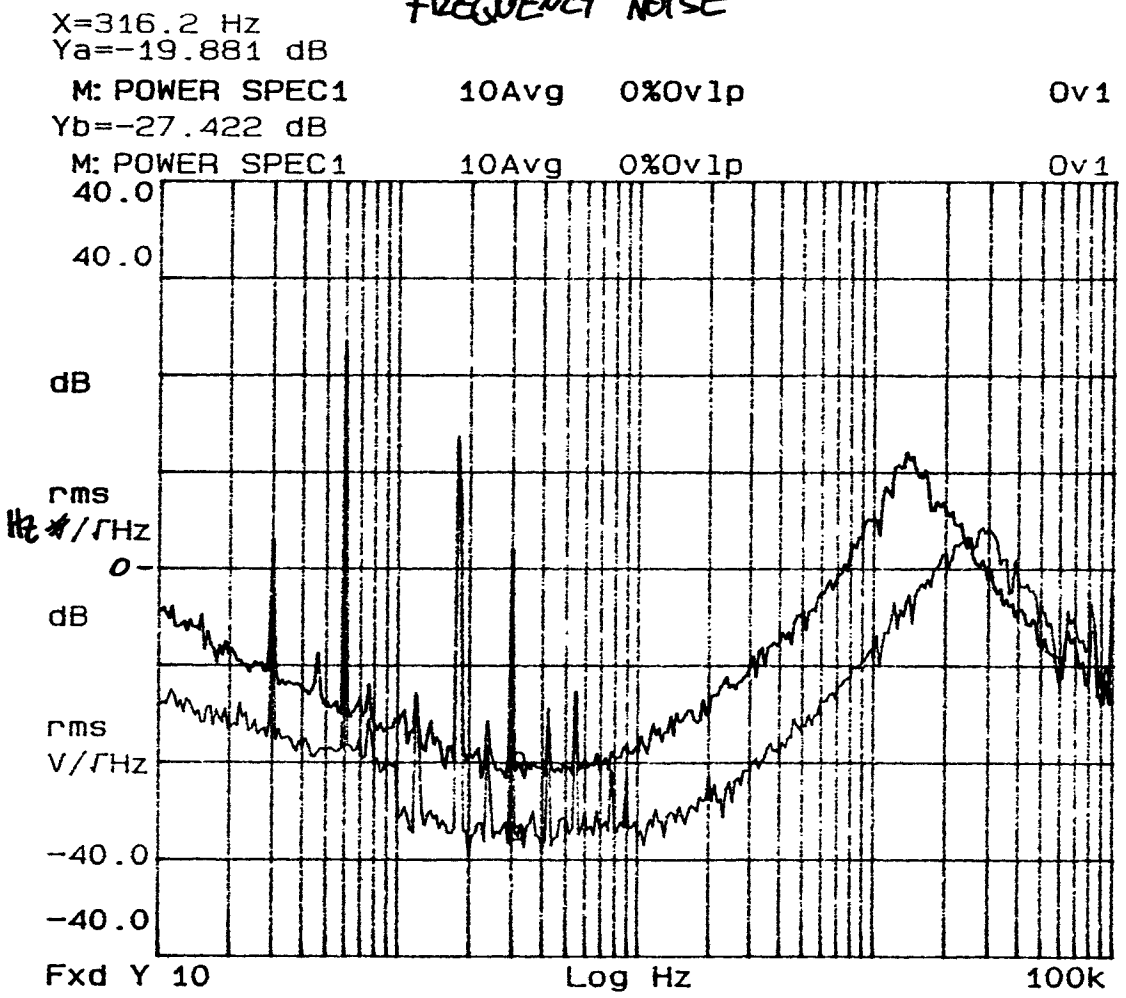
- Simplify!
  - ››Locking achieved using an SR560 and the slow controller
    - — Lower gain than needed, but allowed more careful characterization of the plant, and observation of locking behavior
- Rethink
  - ››New model built in Matlab
  - ››New requirements set (Match Detector Subs. Req. Doc.)
    - — Higher frequency noise allowed, 10 mHz/rtHz
    - — Lower bandwidth O.K. (300 kHz from 1 MHz)
- Redo
  - ››New servo design proposed based on Matlab model
    - — 40 nV/rtHz input referred noise spec'd, 8.9 nV/rtHz predicted
    - — New layout provides for test inputs and monitor outputs
    - — Pockels cell loop designed to be included with new controller
    - — Mixer and traps included on the board

10/16/96 12:00
JEM



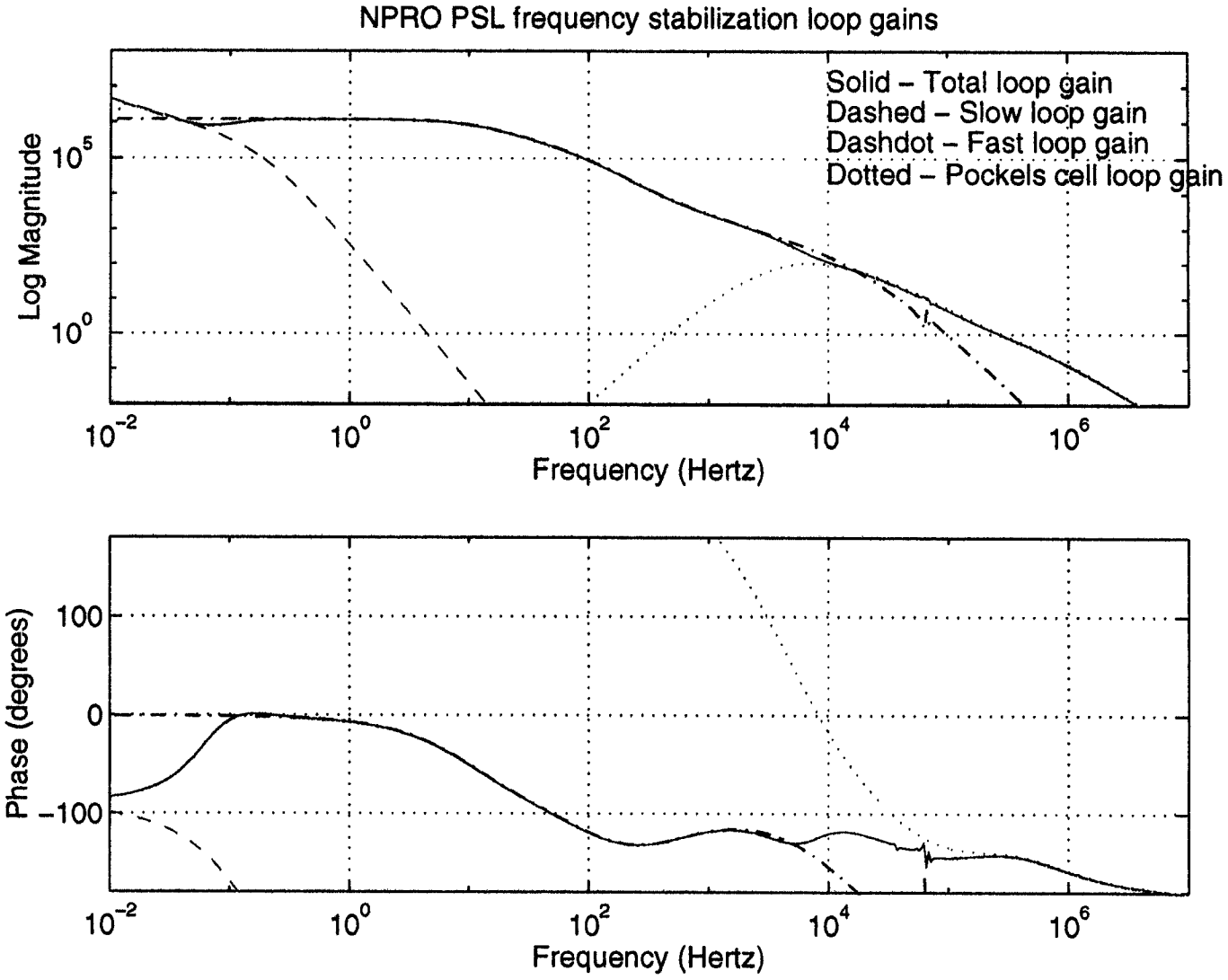
10/18/96 3:00-3:30
JEM

FREQUENCY NOISE

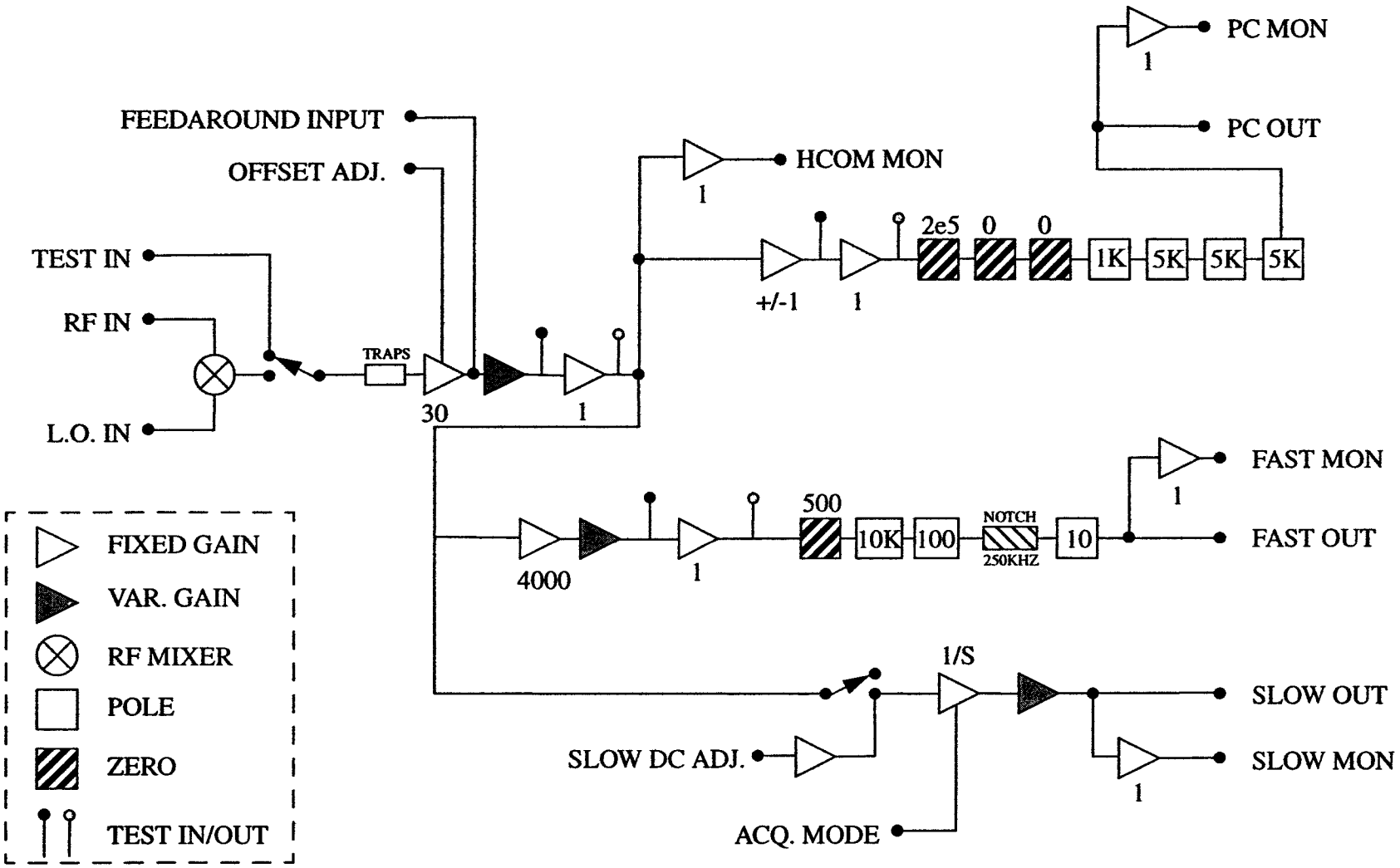


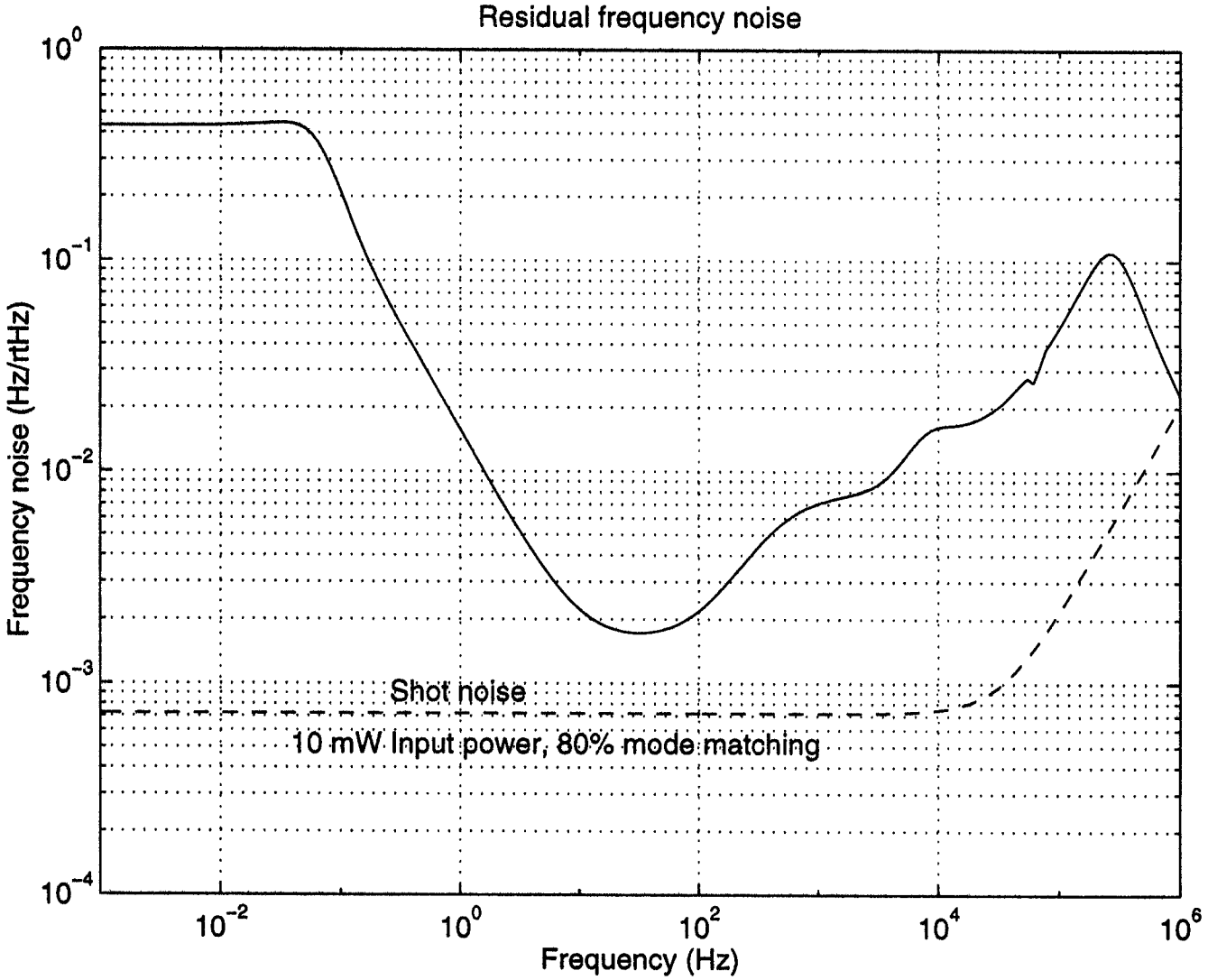
- S/P GAINS
  - BLUE: FAST 1 (×81)
    SLOW .9
  - GREEN FAST 4 (×260)
    SLOW 10
- USES 310 kHz/V

$\frac{260}{81} \rightarrow 10.2\text{dB}$


NPRO PSL frequency stabilization loop gains
Solid – Total loop gain
Dashed – Slow loop gain
Dashdot – Fast loop gain
Dotted – Pockels cell loop gain
Log Magnitude
10^5
10^0
10^{-2}
10^0
10^2
10^4
10^6
Frequency (Hertz)
Phase (degrees)
100
0
−100
10^{-2}
10^0
10^2
10^4
10^6
Frequency (Hertz)

NPRO FREQ. STAB. SERVO




Residual frequency noise
Frequency noise (Hz/rtHz)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
Shot noise
10 mW Input power, 80% mode matching
10^{-2}
10^{0}
10^{2}
10^{4}
10^{6}
Frequency (Hz)

Current status and future plans

- Where we're at
  - ›› New controller being built - expected completion 12/16
  - ›› AOM frequency shifting path laid out and testing has begun
- What's to be done
  - ›› Installation and testing of new controller
  - ›› Frequency shifter path implemented (w/o analyzer cavity)
  - ›› Documentation
  - ›› Delivery to MIT in mid-January
  - ›› Frequency noise measurements made outside the loop done at MIT using the PNI