



# A Very Highly Frequency and Amplitude Stabilized Laser for Precision Interferometry

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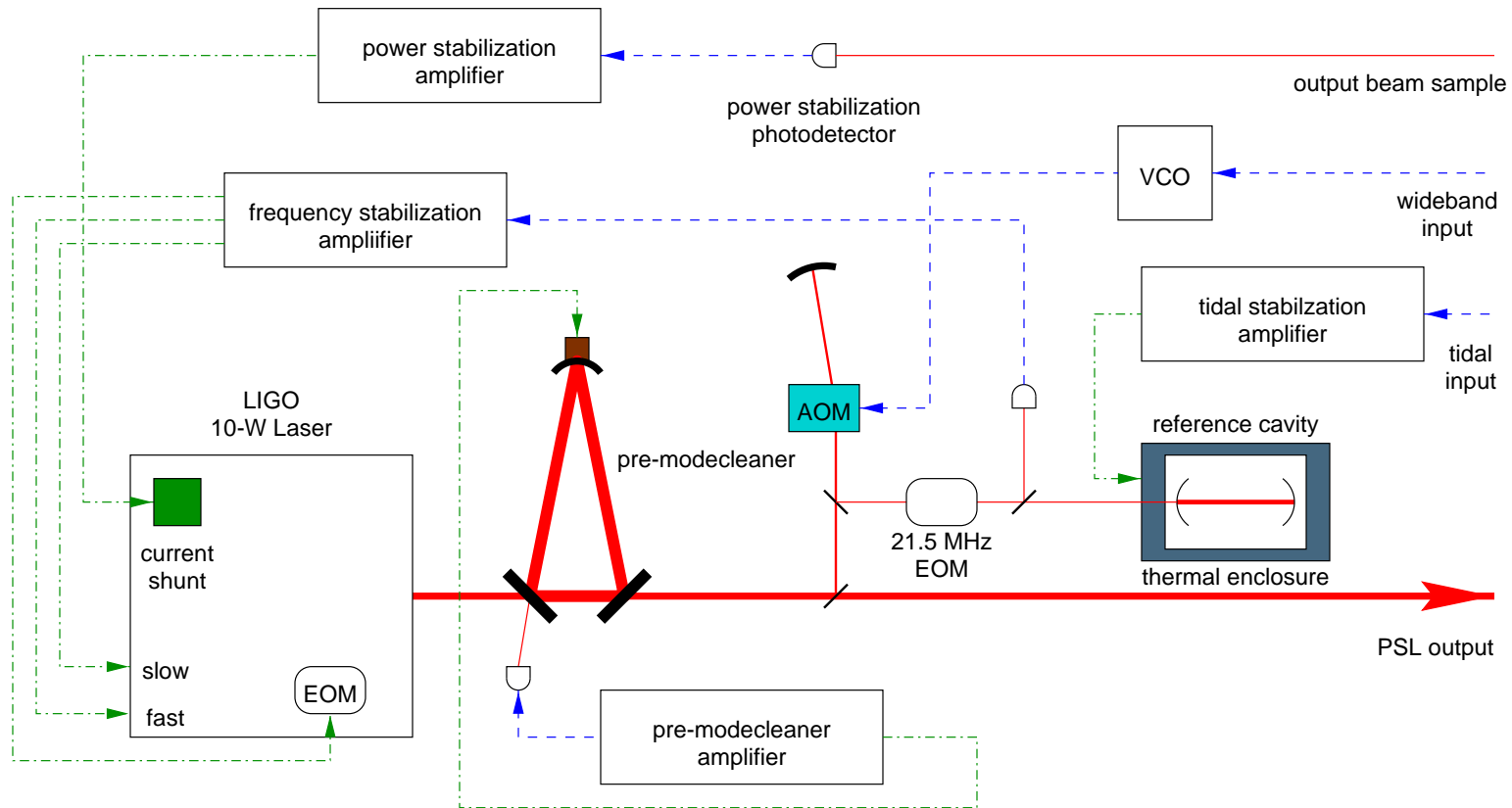
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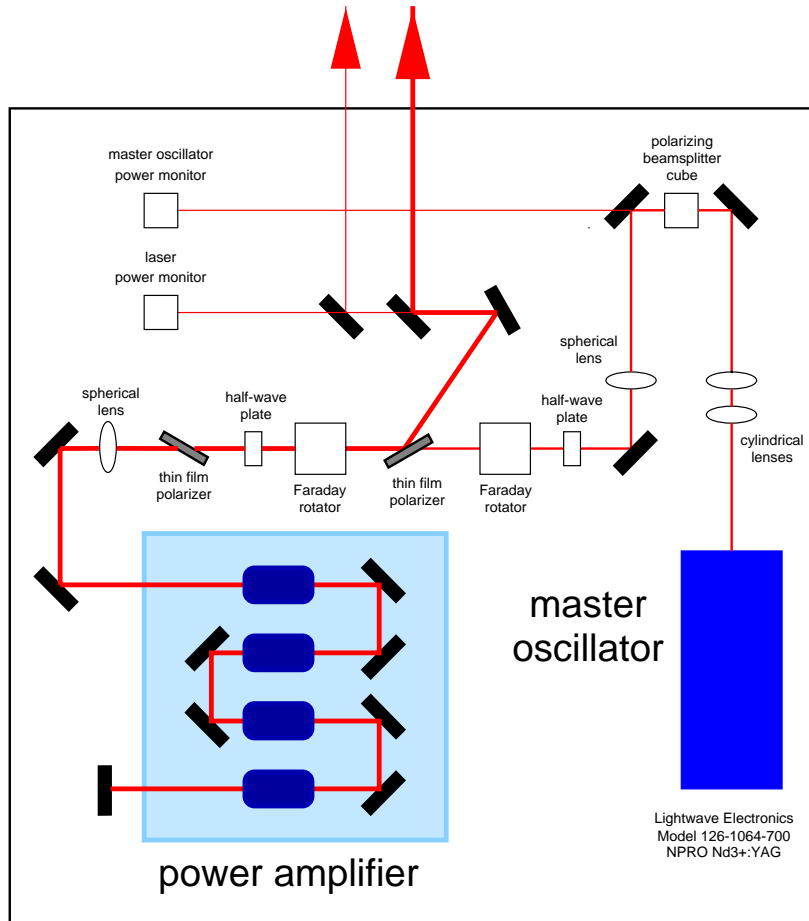
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# PSL Anatomy



# The LIGO 10-W Laser



- Developed under contract by Lightwave Electronics

- » MOPA approach
- » actuators

- frequency  
FAST  
SLOW  
phase correcting EOM  
(installed by LIGO)
- intensity  
POWER

- single frequency,  
single mode, 10 W output

# The Pre-modecleaner

- spatial filter, removes higher order modes from the 10-W laser output
- filters out high frequency power fluctuations (at  $\sim 25$  MHz)
- cavity parameters
  - » low finesse ( $\sim 200$ )
  - » bandwidth  $\sim 1.6$  MHz
- constructed with epoxy, soon to be optically contacted





## The Pre-modecleaner (cont.)

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- high throughput, typically  $> 90\%$  cavity visibility
- acoustically very sensitive
- measurements of the high frequency power fluctuations suggest insufficient filtering
  - » initial assumption was that the NPRO was shot-noise limited at 25 MHz
  - » new lower bandwidth pre-modecleaner under construction



# Frequency Stabilization

- nested loop strategy to get to the frequency noise goal
  - » reference cavity, DC - 5 Hz
  - » suspended modecleaner, 5 Hz - 1 kHz
  - » interferometer, 1 kHz - 1 MHz
- robust performance, high degree of availability
  - » operational for over 20000 hours
- reference cavity parameters
  - » high finesse ( $\sim 10000$ )
  - » bandwidth  $\sim 37.5$  kHz



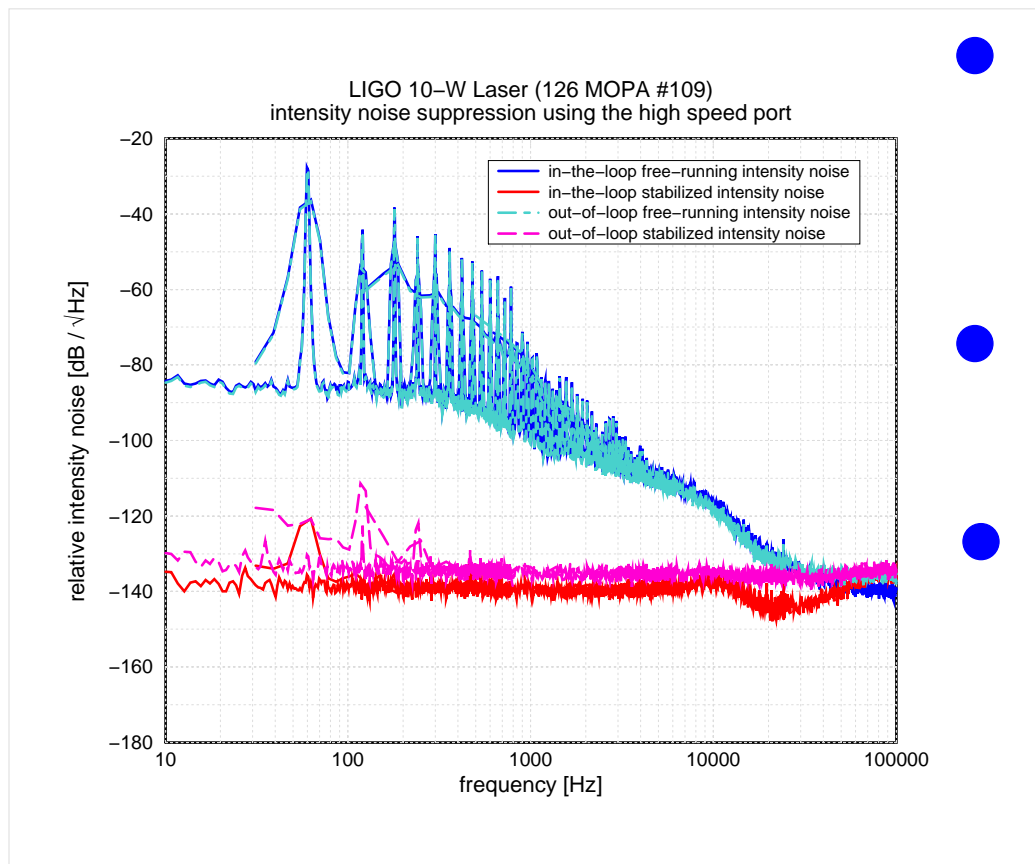
# Frequency Stabilization (cont.)



- close to design requirement
- improvements
  - » acoustic enclosure
  - » improved VCO phase noise



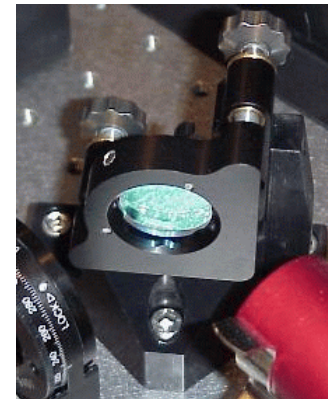
# Intensity Stabilization



- current shunt based
  - » developed at Caltech
  - » integration by Lightwave
- intensity servo currently under development
- specifications tightened to  $-160 \text{ dB}/\sqrt{\text{Hz}}$

# Lessons Learned

- evaluation of mirror mounts
  - » selection based on mechanical resonances
    - most mounts have resonances around 300 Hz
    - commercial mounts stiffened with custom bases
- use fixed, non-adjustable
- periscopes
- minimize optical path lengths and reflections





# Current Status

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- all 3 LIGO PSLs are operational and are undergoing commissioning
- steady improvement in laser noise performance
  - » electronics
  - » seismic induced noise at Livingston
  - » elimination of excitation sources
- prototype intensity stabilization installed
  - » achieved an out-of-loop figure of  $3.0E-8$  from 100-800 Hz
- tidal servo currently being worked on
  - » discrepancy between measurement and prediction