LIGO II Pre-stabilized Laser System Design Requirements and Conceptual Design

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LIGO II PSL Design Requirements

- Output power delivered to IO system
  - » 150 watts in a circular TEM_{00} mode (8.5 W for LIGO I)
- In-band relative intensity noise
  - » 3×10^{-9} 1/rtHz (1×10^{-8} for LIGO I)
- Relative intensity noise at GW modulation frequency
  - » ASD < 1.005 times shot noise for 5 W of light (600 mW for LIGO I)
- Frequency fluctuations at PSL output
  - » 100 mHz/rtHz at 100 Hz (same as for LIGO I)
  - » 10 mHz/rtHz at 1 kHz and above (same as for LIGO I)
- Wideband and Tidal Actuators (same as for LIGO I)

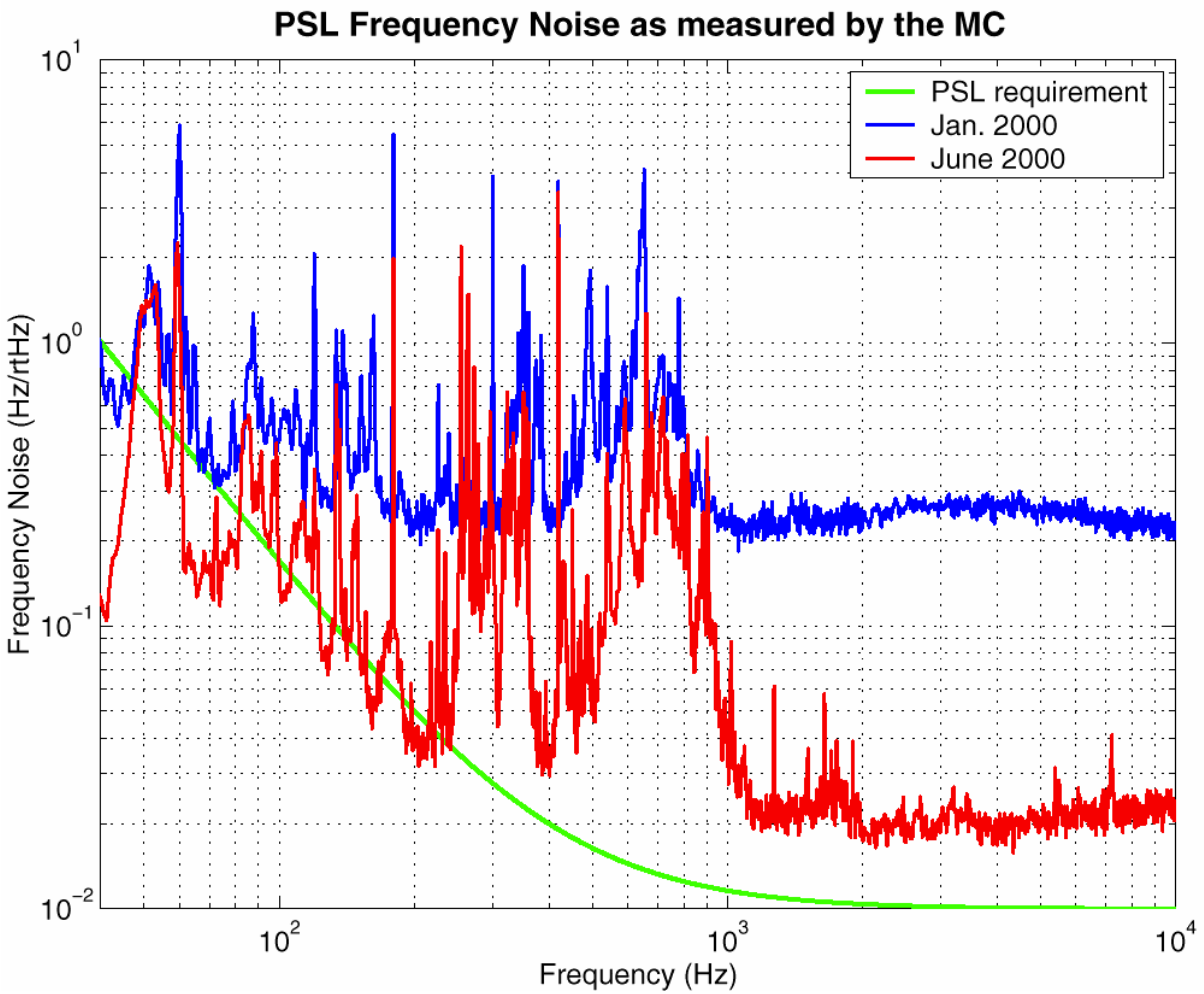
Status of LIGO I PSL Performance

- Output power delivered to IO system
  - » 6-8 wattts
    - – no serious effort made to optimize operating parameters – MO and PA current and temperature
    - – Alignment and modematching into power amplifier required
    - – Mountig of EOM between MO and PA complicates alignment
    - – LHO system operated continuously for > 18 months
- In-band relative intensity noise
  - » Staiblization AFTER modecleaner not yet attempted
    - – Photodetector and preamplifier not yet designed or fabricated
    - – Currrent shunt actuator designed and implemented

LIGO I PSL Status (cont.)

- Relative power fluctuations at GW modulation freq.
  - » Pre-modecleaner
    - – Operating continuously for > 18 months at LHO
    - – Sensitive to atmospheric pressure fluctuations
    - – Sensitive to acoustics
    - – Sealing or housing inside a sealed chamber planned
    - – Finesse ~ 2-3 times too low
- Frequency fluctuations
  - » Approaching requirements
    - – Optical layout optimization
    - – Acoustic shielding
    - – Pick off reference cavity beam AFTER PMC – P. King testing on hold

Frequency Servo Performance



N. Mavalvala

P. Fritschel

LIGO II PSL Conceptual Design

- Strategy
  - » Develop ONE concept even though numerous options exist and requirements are still in a state of flux
  - » Propose design for LIGO II laser even though LIGO is pursuing procurement from commercial vendor.
  - » Build on experience with LIGO I PSL
  - » Utilize hardware and software from LIGO I PSL (already paid for)
- Goals
  - » Demonstrate that requirements are reasonable and realizable
  - » Provide Peter King and Rich Abbott information required for cost estimate
  - » Provide Gary Sanders conceptual design description for NSF proposal.

LIGO II PSL Concept Overview

- Laser source (Todd Rutherford)
  - » LIGO I 10-W laser modified to produce 20 watts as front end.
  - » Two-stages of zig-zag slab amplifiers
  - » Laser pre-modecleaner (LPMC) between front end and amplifiers
- Itensity stabilization (David Ottaway)
  - » LPMC and PMC
    - – Circulating powers about 10 times LIGO I
  - » Pwr. Stab. PD inside the vacuum envelope
- Frequency stabilization
  - » Beam for reference cavity sampled AFTER PMC
  - » All hardware and software same as for LIGO I

- Wideband actuator
  - » Same as for LIGO I PSL
    - – VCO range reduced to enable noise reduction
- Tidal acutator
  - » Same as for LIGO I PSL
- Diagnostic modes
  - » Removed from PSL scope
  - » Some power modulation may be achievable via power stabilization loop

LIGO II PSL Concept (cont.)

- New Features
  - » Laser Room similar to Livingston enclosure
    - – Electronics racks moved outside room
    - – > 20 dB acoustic attenuation
    - – Controlled thermal environment
    - – Controlled access
  - » Active vibration isolation system for IO/PSL optical table
  - » Output power reduction with complementary increase in power to reference cavity and PMC RFPDs
  - » Laser power supplies located outside Laser Room near other eclectronics racks
  - » Chillers for lasers located remotely in Mechanical Rooms

LIGO II PSL Upgrade Options

- Laser source (Peter Veitch)
  - » Injection-locked oscillator for front end
  - » Stable-unstable resonators
- Frequency stabilization