

The GEO 600 Laser System

LIGO-G010366-00-Z

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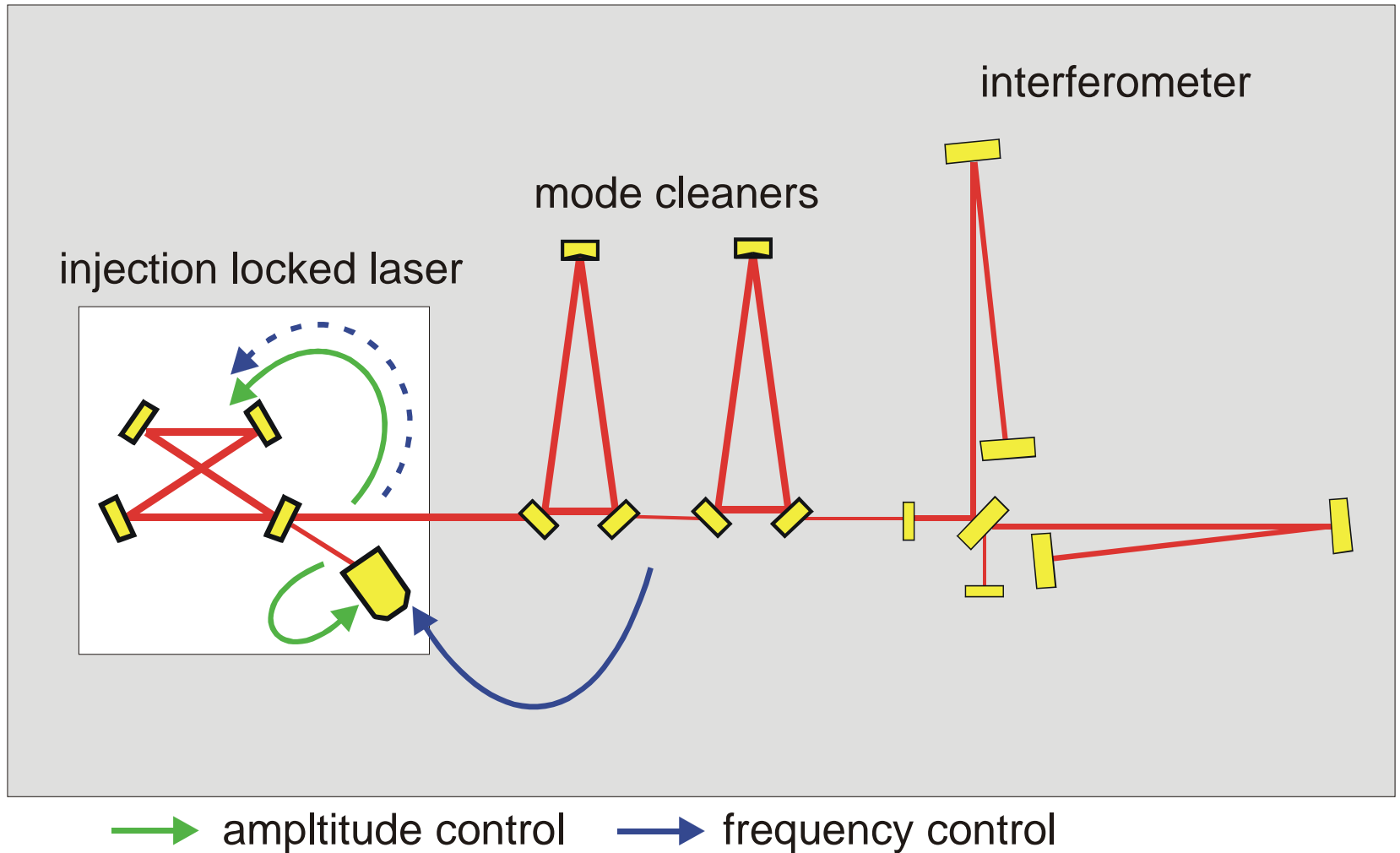
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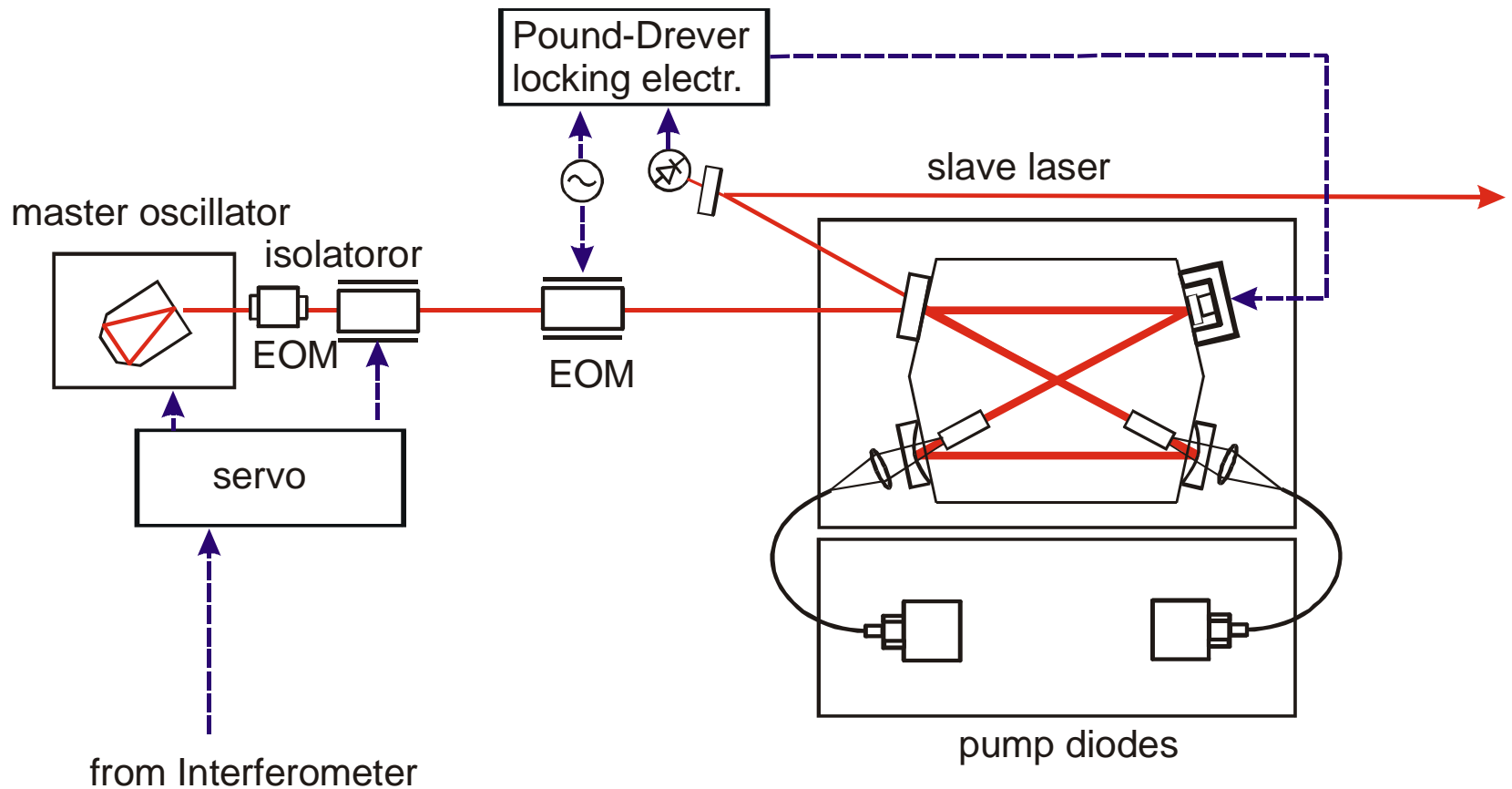


Scheme GEO600 PSL



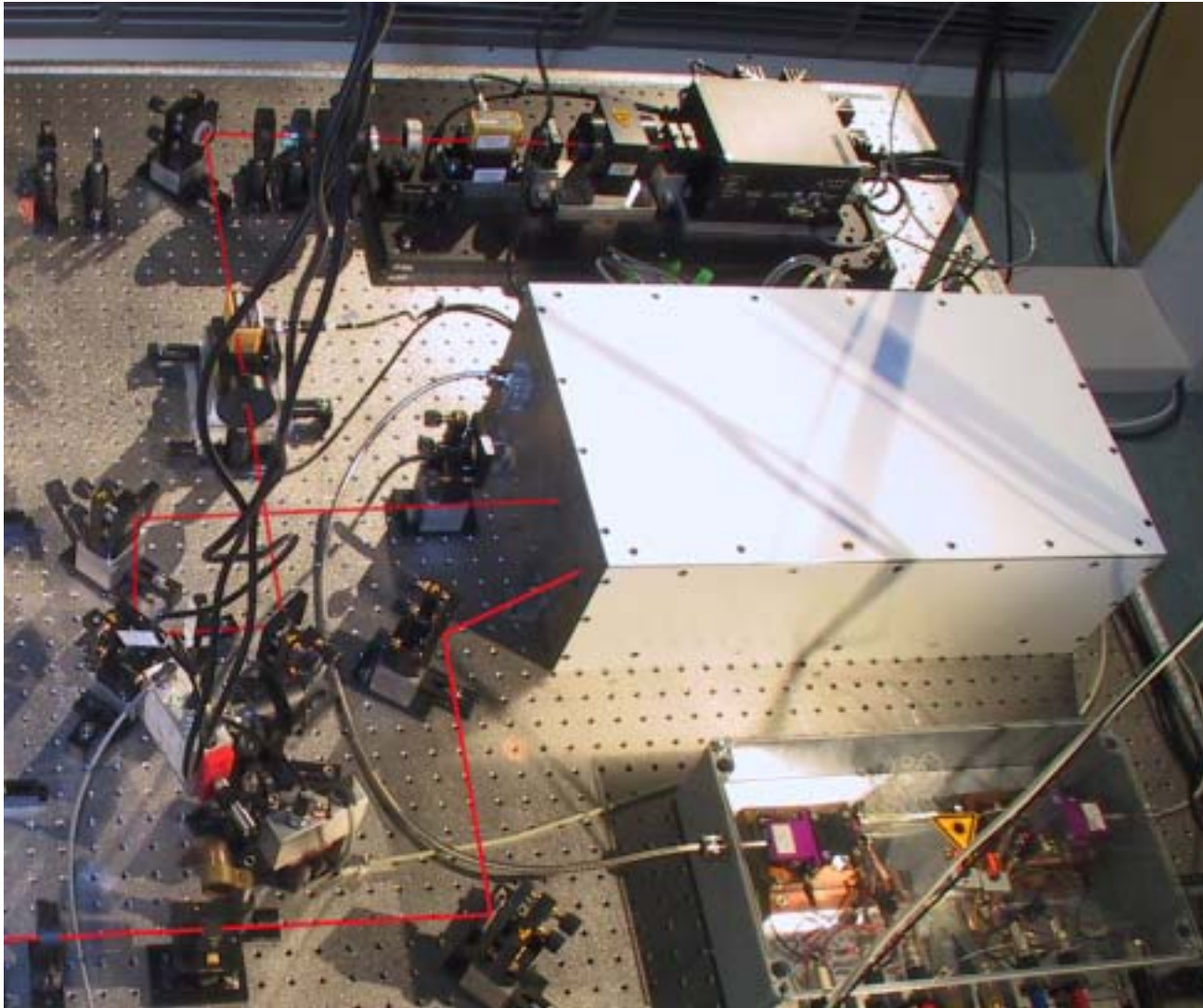
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Scheme of the Injection Locked Laser System



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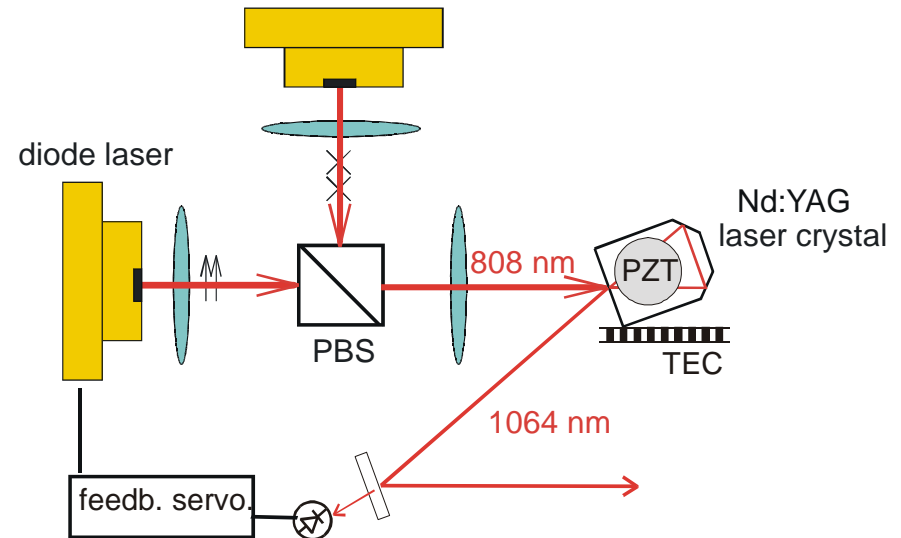
Injection Locked Laser System



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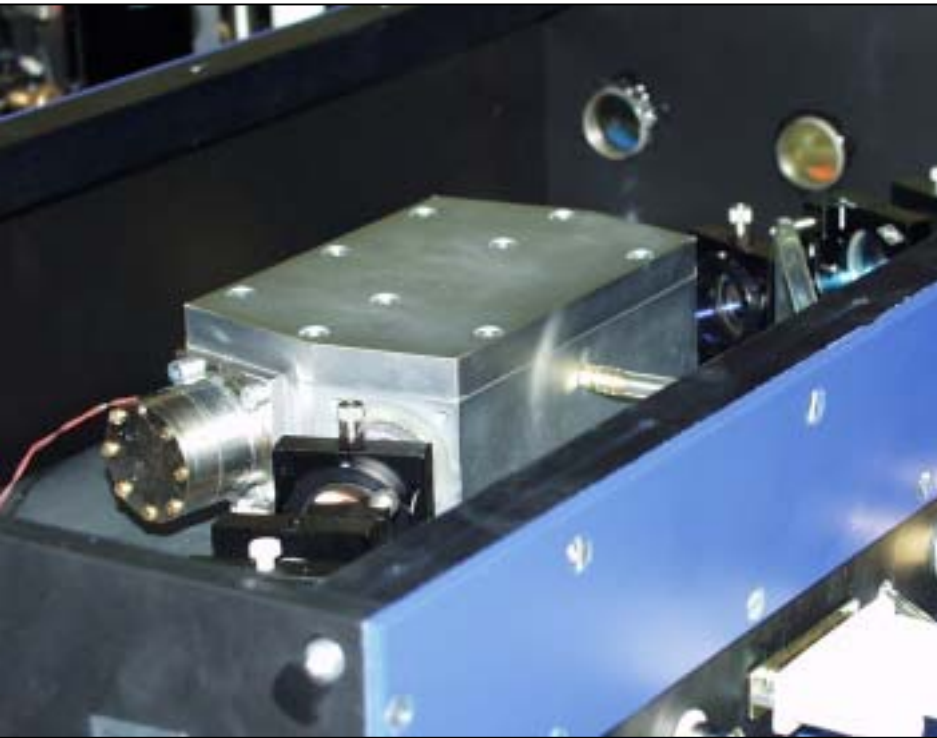
Master: Monolithic Nd:YAG NPRO

- 800 mW single frequency
- RRO and intensity noise suppression (> 100 Hz) by electronic feedback
- Frequency control by
 - temperature
 - 3 GHz/K (dc)
 - bandwidth 1 Hz
 - piezo
 - 2 MHz/V
 - bdw. typ 50 kHz limited by mech. resonances
 - pump power
 - 1 MHz/mA (dc)
 - 1/f dependency $f > 100$ Hz
 - bdw. 100 kHz
 - no observable beam pointing
- External EOM for fast phase control



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Slave: Quasi monolithic Nd:YAG Laser

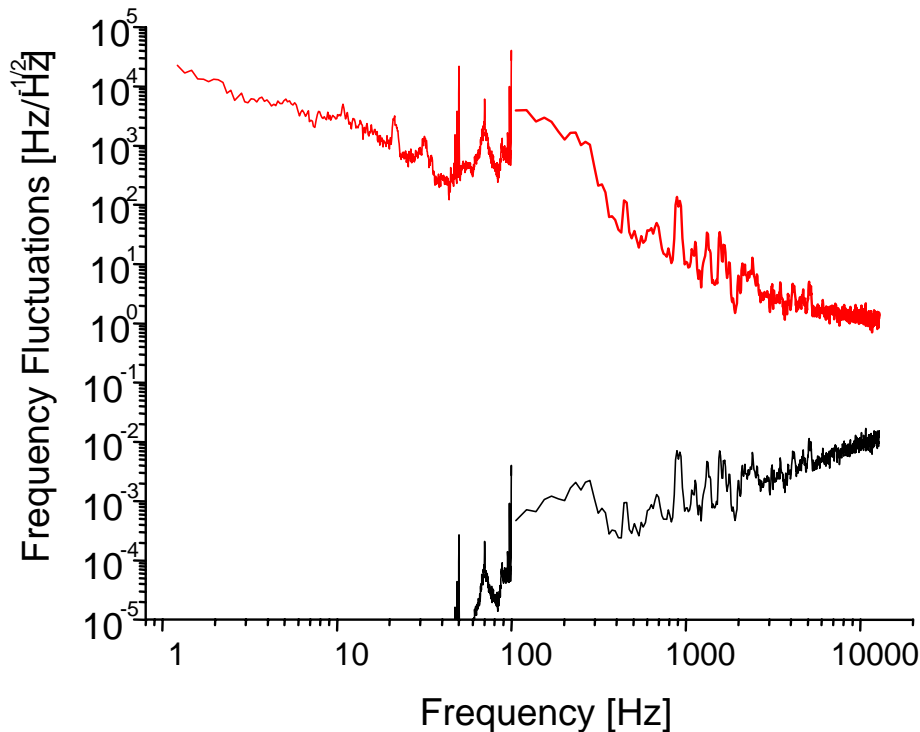


bow-tie ring with two end-pumped rods

- > 12 W, $M^2 < 1.1$, DOP > 98%
- > 35 % optical efficiency
- 1 midrange piezo length actuator
 - 2.5 μm (2.5 GHz) / -15 to 300 V
 - max. Voltage -100 V to 500V
 - resonances > 50 kHz,
 - bandwidth 15-20 kHz
 - dc tilt typ. 10 μrad / μm
- Quasi monolithic design
 - no manually movable resonator parts
 - low thermal expansion spacer
 - Invar: $\alpha = 8 \times 10^{-7}/\text{K}$ -> 225 MHz/K
 - (air at 1000 hPa -> -250 MHz/K)
 - (Alu: $\alpha = 24 \times 10^{-6}/\text{K}$ -> 6.7 GHz/K)

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Slave: Quasi monolithic Nd:YAG Laser



- quasi monolithic slave relative to stabilized NPRO
- calculated influence on system with 1 MHz locking range and 1 kHz servo

Piezo range requirements (calculated):

- 25 MHz / K
- 80 MHz / mbar : 50 mbar p-p: 4 GHz

Deviation from center of locking range

- RMS 1 Hz -100 kHz: ca. 500 Hz which is 3×10^{-4} of locking range

Slave influence on frequency noise

- comparable with free running master (not injection-locked)
- follows stabilized master (when injection-locked)

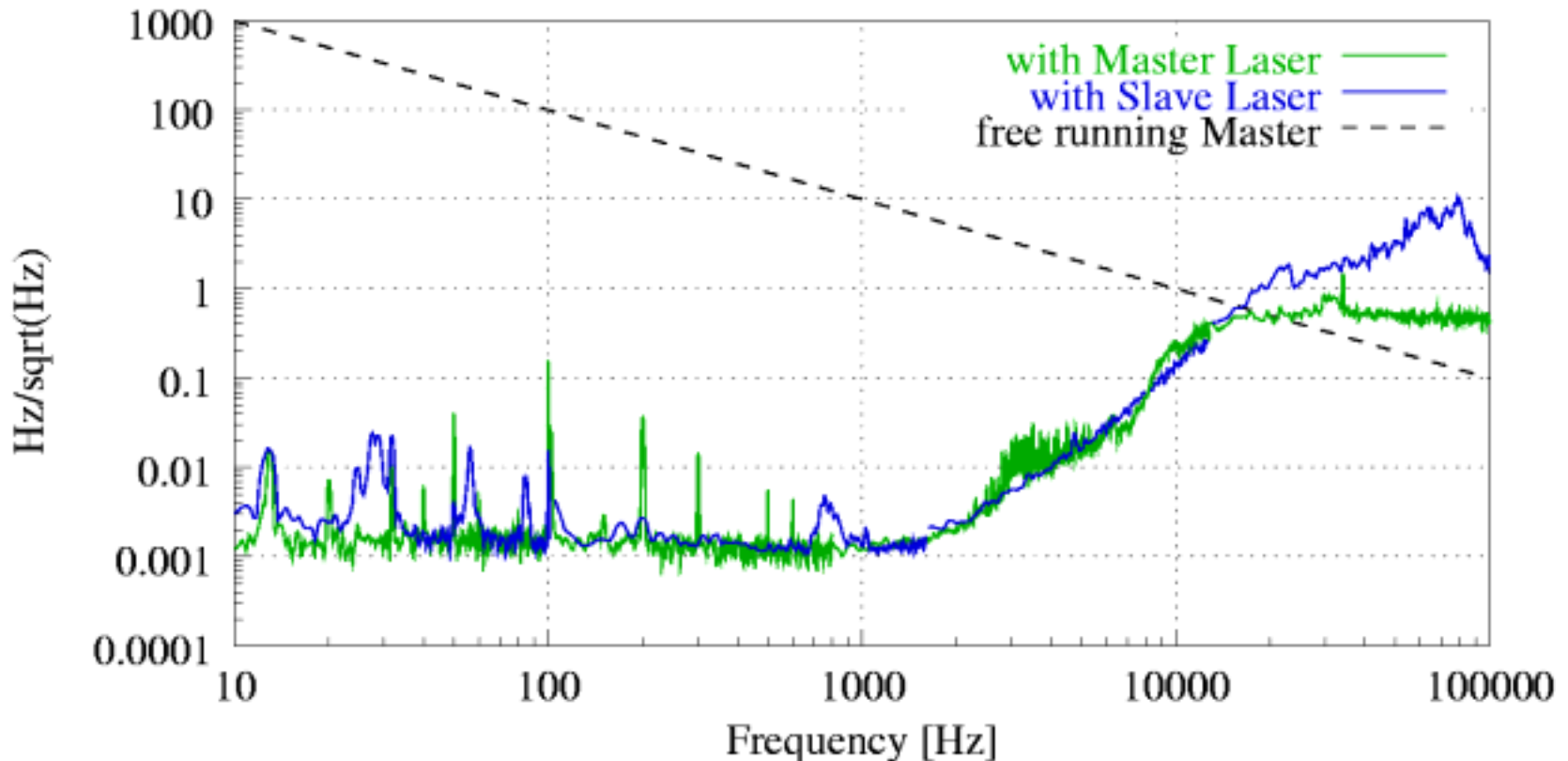
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Short Term System Performance

- Locking range 1.6 MHz
- 94% visibility at first mode cleaner achieved
- No influence of slave to system frequency stability observable
- Amplitude prestabilization at detection band frequencies ...

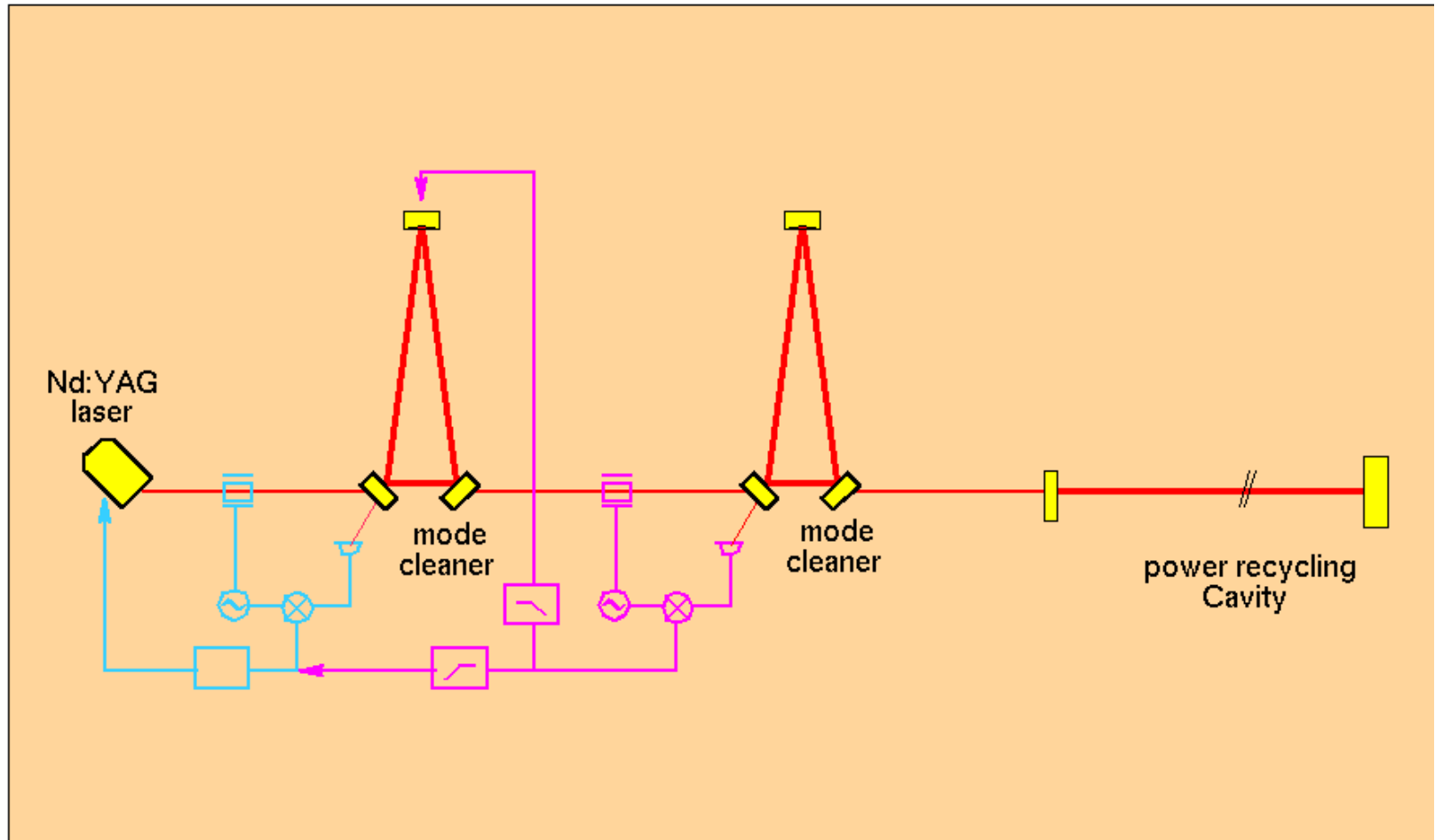
Frequency Noise

- Inloop frequency noise at the first modecleaner: 1 mHz
- Performance does not degrade with high power laser



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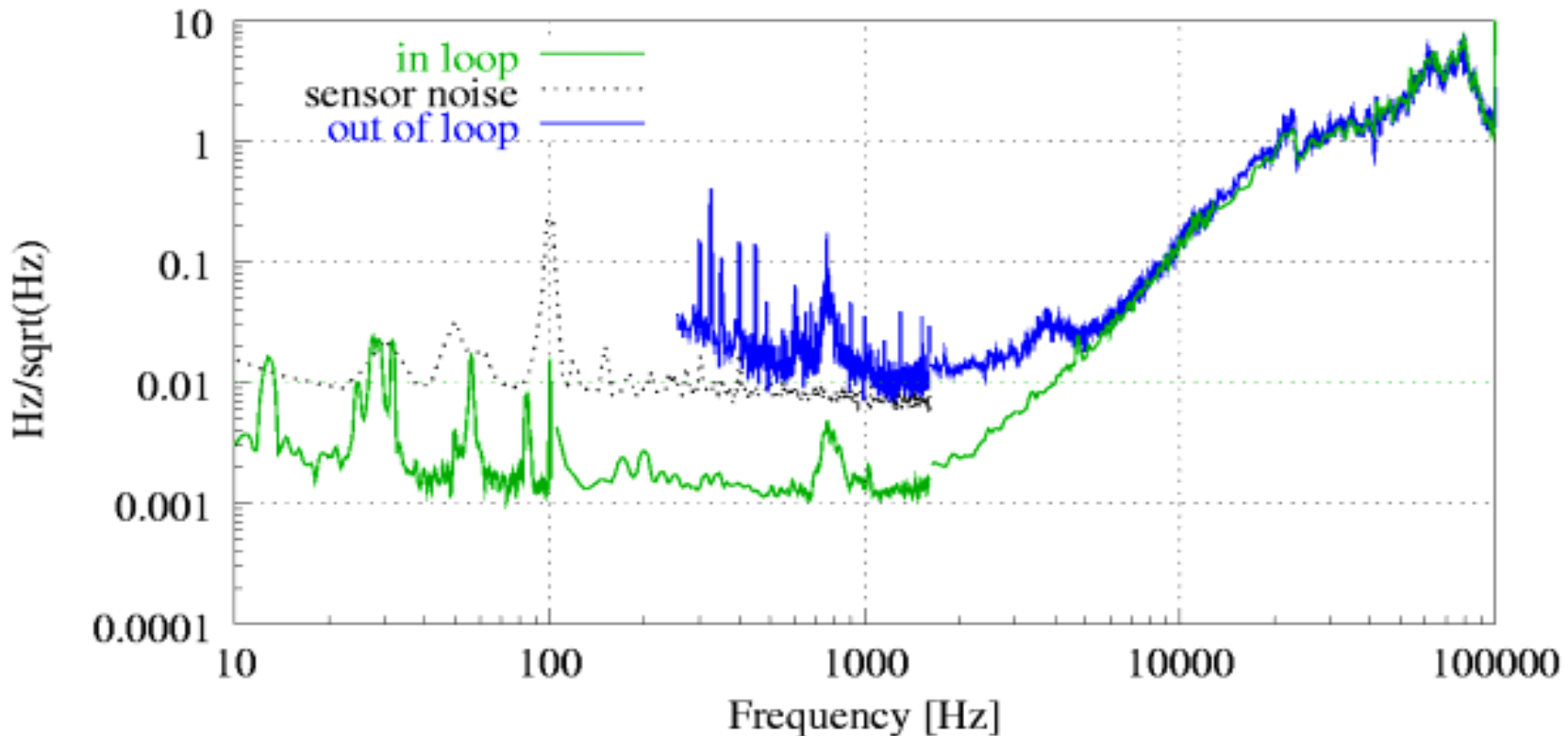
Out of Loop Measurement



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Modecleaner Frequency Noise

- The out-of-loop frequency noise at the first modecleaner: 10 mHz

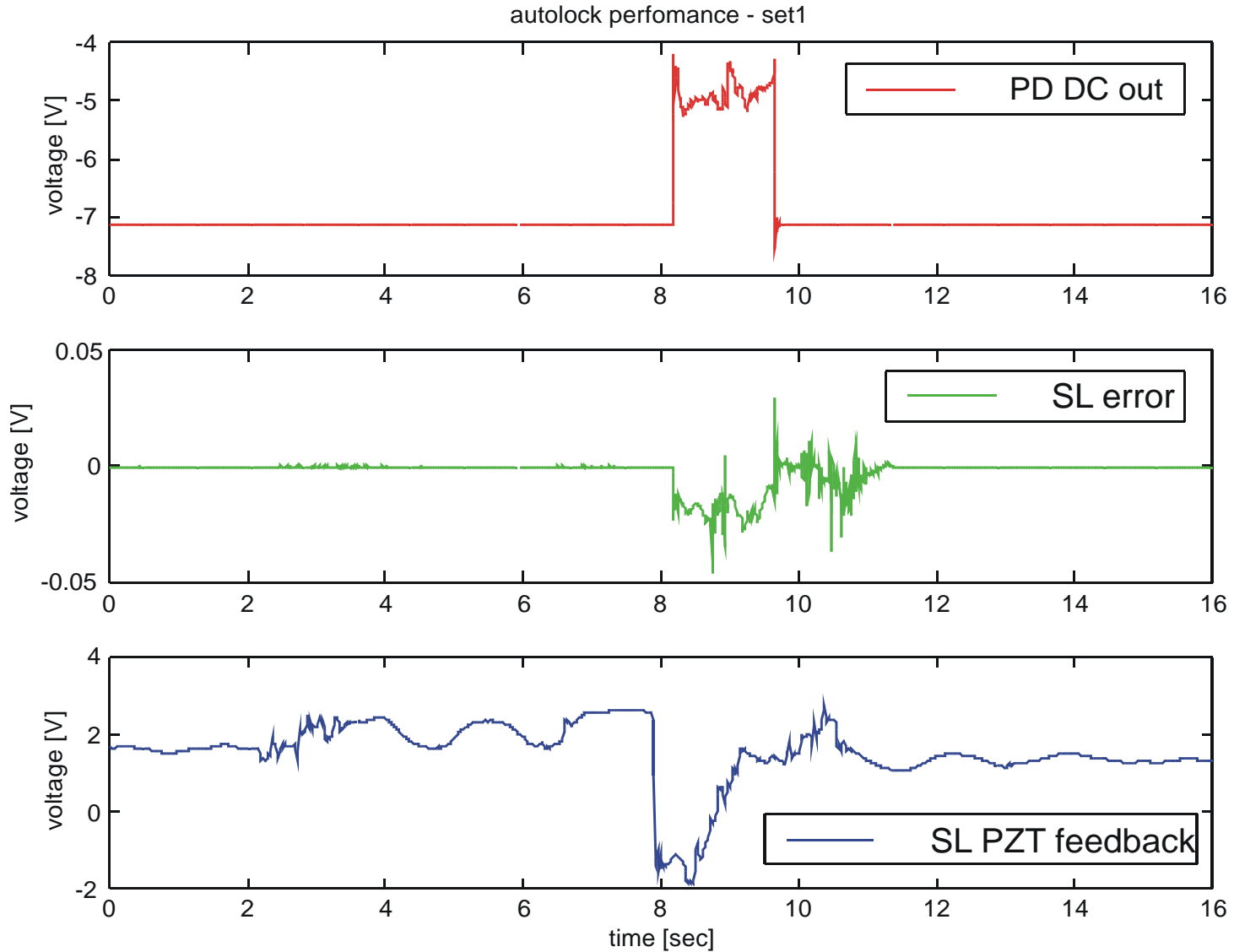


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Autolock Slave to Master

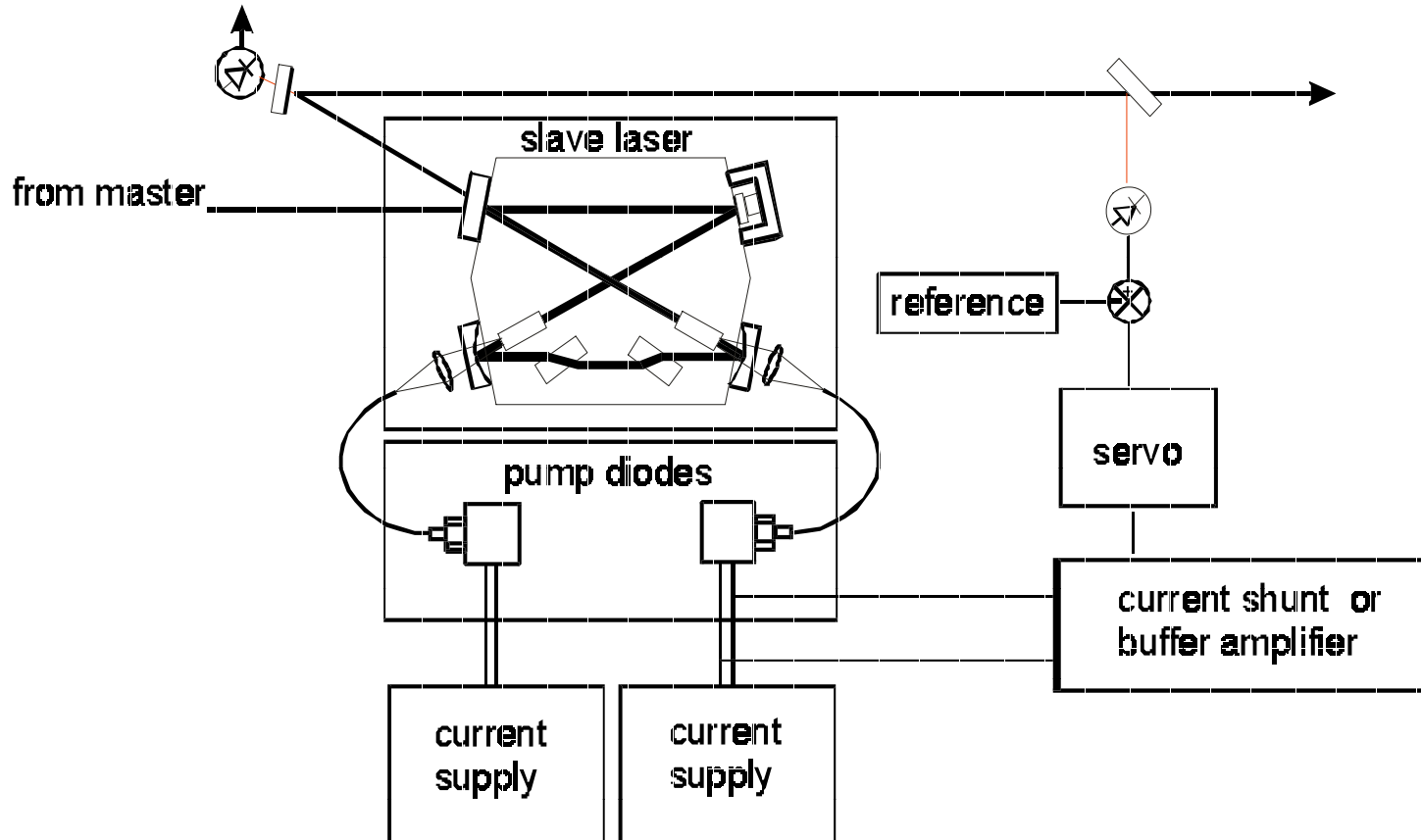
- State (locked/unlocked) distinguished by output power
- Ramp slave cavity length to achieve transient injection lock
- Keep lock by switching from ramp to servo
- Typ. lock acquisition time 5 s (max. 20 s)

Autolock Performance



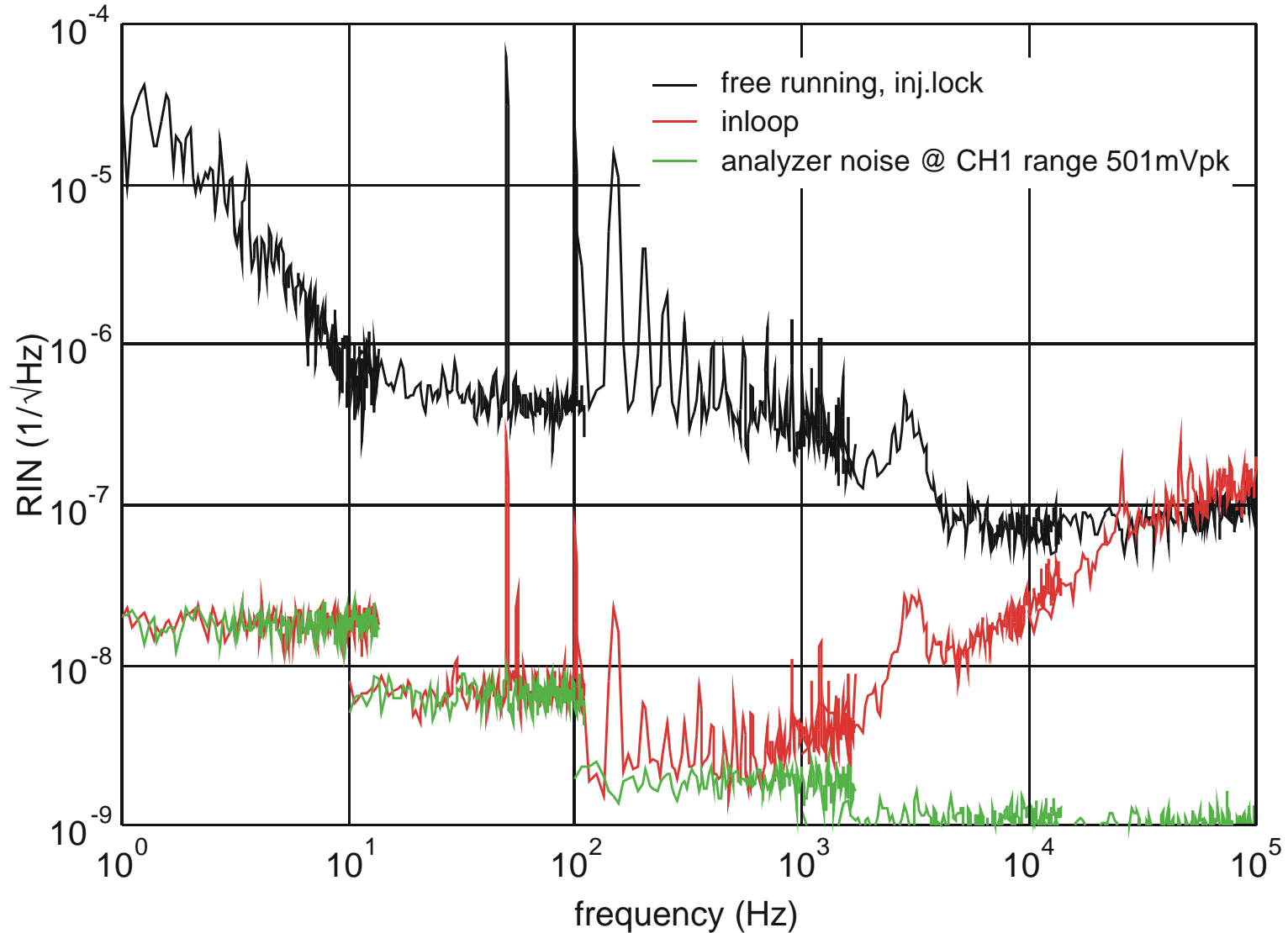
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Intensity Prestabilization



Intensity Noise Control – inloop

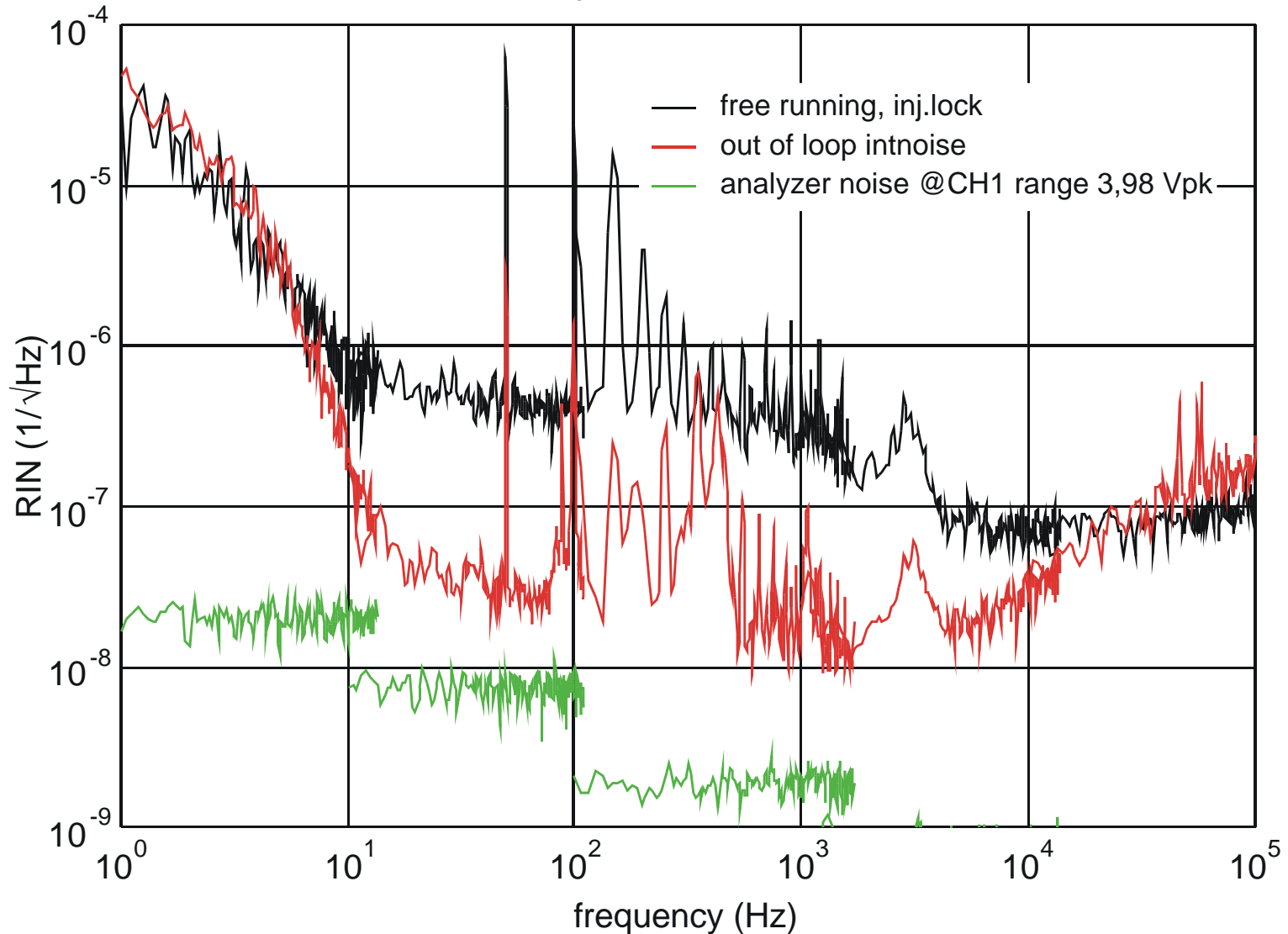
10.08.01; HP-FFT:DC&GND, 10 avg.; PreAmp:x100, low noise, 2HP@0,03Hz; U_DC=-6,5V



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Intensity Noise Control - Out of loop

10.08.01; HP-FFT: DC&GND, 10 avg.; PreAmp: x100, low noise, 2HP@0,03Hz; U_DC=-4,6 V



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