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PHOTON ACTUATION R&D PROGRAM

Michael Smith

8 Oct 02

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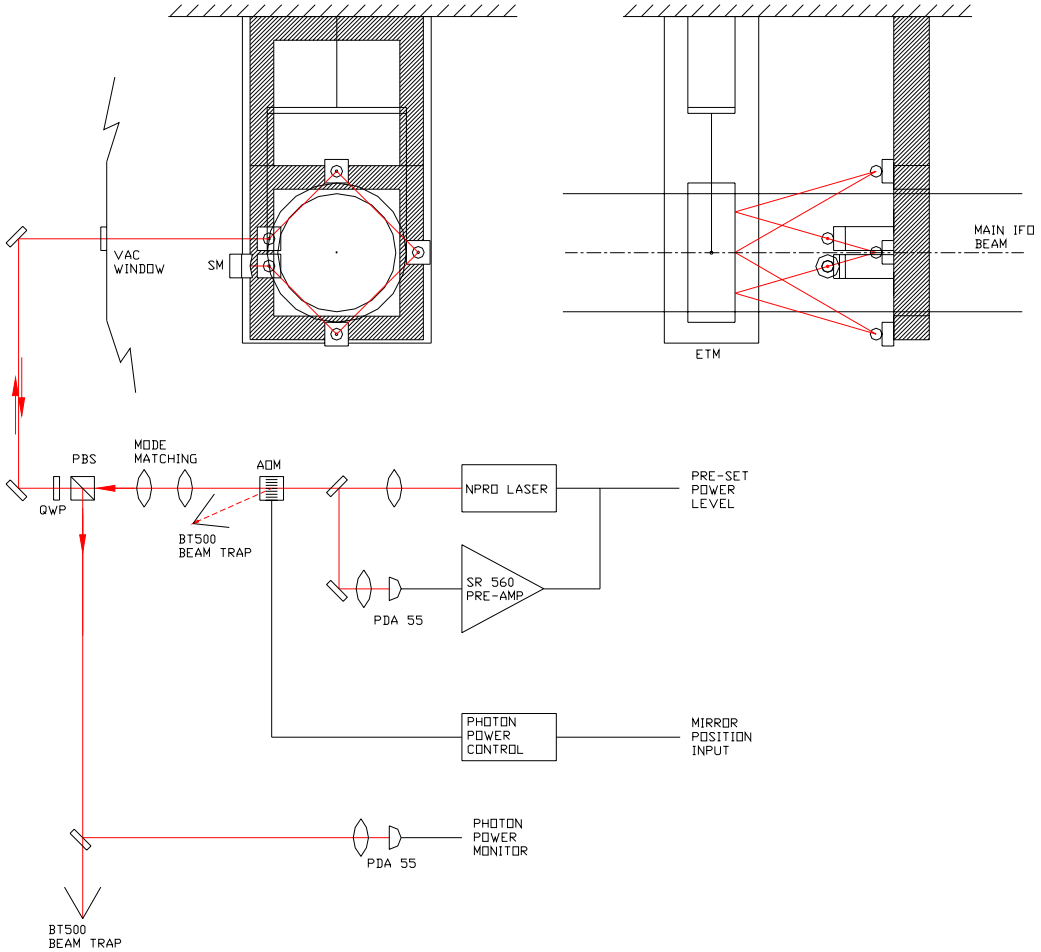
Current Status

- Preliminary concept- completed by Mike Zucker, 10/13/00
- Updated conceptual design- completed by Mike Smith, 10/1/02

Photon Actuator Conceptual Design



Photon Actuator R&D Plans for 2003

- Finalize Design Requirements & Conceptual Design
- Preliminary design, Adv LIGO Photon actuator
- Simulink modeling, Adv LIGO photon actuator and quad pendulum suspension
- Design & build 40m breadboard photon actuator
  - Intensity stabilized NPRO
  - photon actuator opto-mechanical assembly
  - servo-controlled IFO mirror displacement
- IFO Mirror actuation experiment in 40m IFO

Photon Actuator System Requirements

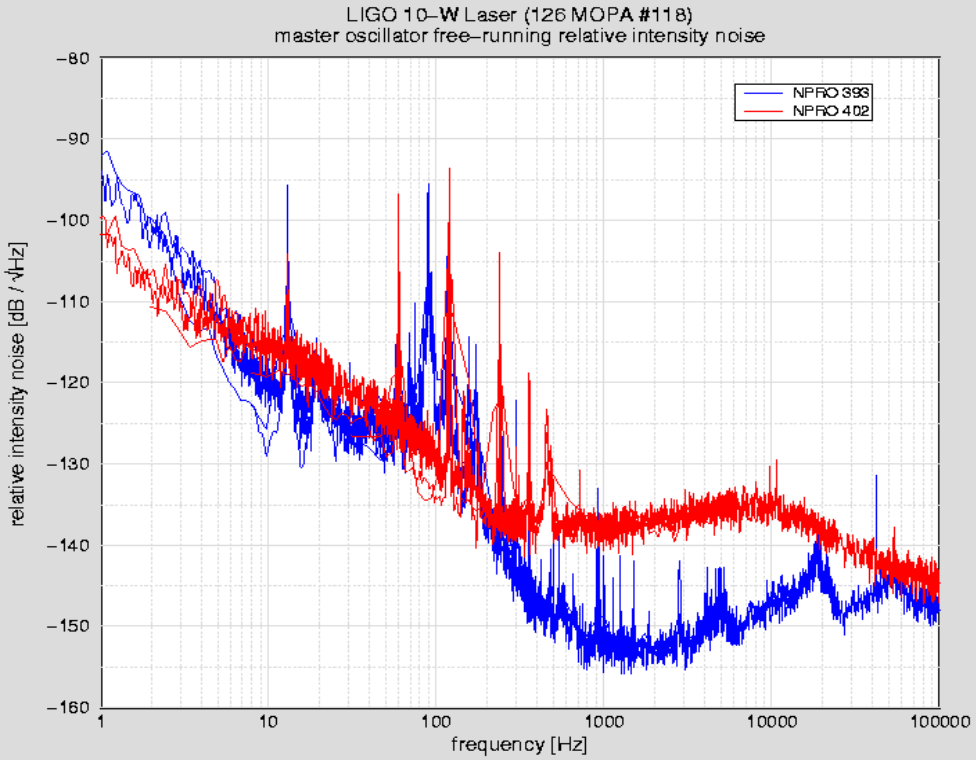
• Mirror actuation force[1], RMS	1×10^{-11}	N
• Mirror actuation force[1], peak	1×10^{-10}	N
• Actuator force noise spectrum[1]	$< 2.5 \times 10^{-15}$	$N/Hz^{1/2}$
• Working frequency range[1]	10 – 10000	Hz

•1. Global Control Issues for Adv LIGO Quad Suspensions, G010086-00-D, Peter Fritschel, 3/16/01

Photon Actuator Design Values

- Laser power — 0.5 — W
- Number of bounces — 8
- Photon force, RMS — $F_{RMS} = \frac{2NP}{\sqrt{2}c} = 1.9x10^{-8}$ — N
- Shot-noise-limited sampled laser power — $> 64x10^{6}$ — W
- Photon force noise spectrum — $\tilde{F} \le 2.5x10^{-15}$
- Laser power noise spectrum — $\tilde{P} \le \frac{c}{2N}\tilde{F} = 4.7x10^{-8}$ — W/rtHz
- Relative intensity noise — $\frac{\tilde{P}}{P_{RMS}} \le \frac{4.7x10^{-8}}{0.5} \approx 10^{-7}$ — 1/rtHz

NPRO
Relative Intensity Noise



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Technical Risks and Opportunities

- The main technical risk is to achieve a relative intensity noise ratio (RIN) of <–140DB (10^{-7}) with an intensity-stabilized NPRO laser, in the gravity wave band 10 Hz to 10000 Hz (according to Peter King, the risk is very low.)
- The breadboard experiment relies on the 40m IFO being operational and accessible during the summer 2003
- Good opportunity to use the 40m IFO for an additional Advanced LIGO R&D task

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Schedule Issues

- Jan – May 2003 Design and Analysis
- June - Aug 2003 Breadboard experiment

- Experiment conducted during the summer in order to utilize 2 SURF students
- 40m IFO should be operational during summer 2003

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Cost Baseline

• Fabricated parts	$ 1000
• Purchased lab equipment (note 1)	$14000
Total cost estimate	$15000

note 1: assumes the loan of the following equipment:

1ea NPRO laser

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Purchased Parts

• Fabricate photon actuation tower	$ 1000
• Polarization beam splitter	580
• BS and mirrors (7)	1490
• Quarter wave plate	510
• Steering mirrors (5)	600
• PDA 55 (2)	1000
• Lens (5)	1000
• SR 560 (2)	5000
• Kinematic stage	415
• AOM & driver	1530
• Beam trap (2)	450
• Video camera	500
• Miscellaneous	1000

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Staffing Baseline and Issues

The following personnel, or equivalent, will be needed to complete the 2003 R&D program

• Michael Smith	480 hrs
• Mark Barton	240 hrs
• Electronic Engineer	132 hrs
• Osamu Miyakawa	320 hrs
• SURF student 1	400 hrs
• SURF student 2	400 hrs
total	1972 hrs

Note: Alan Weinstein also available