eLigo pre-stabilized laser (and part of input optics) upgrade

Rick Savage
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People involved

35-W laser/advLigo PSL

AEI - Hannover
- Hyunjoo Kim
- Patrick Kwee
- Frank Seifert
- Benno Willke

LZH
- Maik Frede
- Dietmar Kracht
- Bastian Schulz
- Christian Veltkamp
- Sascha Wagner
- Peter Wessels
- Lutz Winkelmann
- Oliver Punken

eLigo/advLigo PSL

Caltech
- Rana Adhikari
- Stefan Ballmer
- Lee Cardenas
- Peter King

LLO
- Mike Fyffe
- Antonio Lucianetti – U of F
- Valera Frolov

LHO
- Anamaria Effler
- Rick Savage
- Paul Schwinberg
- Jamie Rollins – Columbia

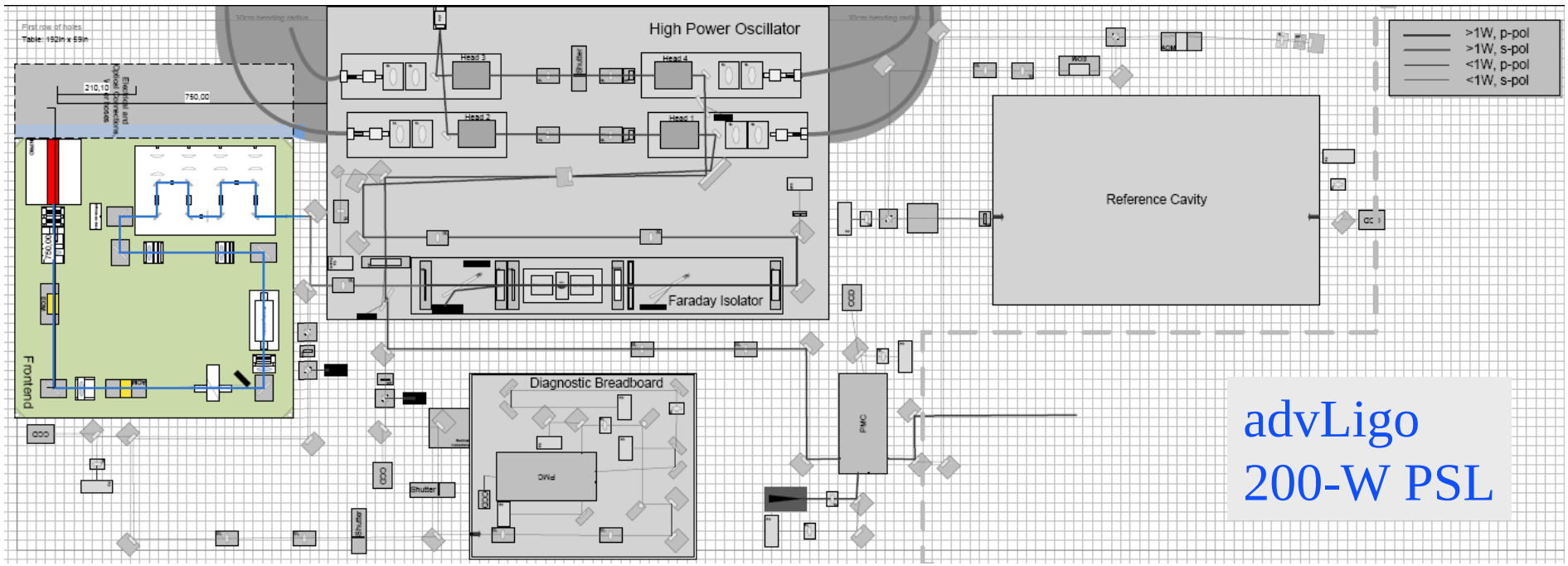
U of F
- Volker Quetschke

Scope

- Upgrade PSLs from iLigo to include 35-W laser source that will be part of advLigo 200-W laser.
- Upgrade to advLigo-style (three-frequency) EOM and power control - part of Input Optics subsystem
  - » both H1 (Hanford) and L1 (Livingston) interferometers
  - » ~ 3.5 x increase in power over iLigo
  - » modify control loops and optical hardware to accommodate different laser source and higher power
  - » achieve eLigo performance parameters (frequency noise, intensity noise, beam quality, optical efficiency, reliability, etc.). Similar to advLigo requirements.
  - » operate during eLigo commissioning and S6 science run to gain experience relevant to advLigo.

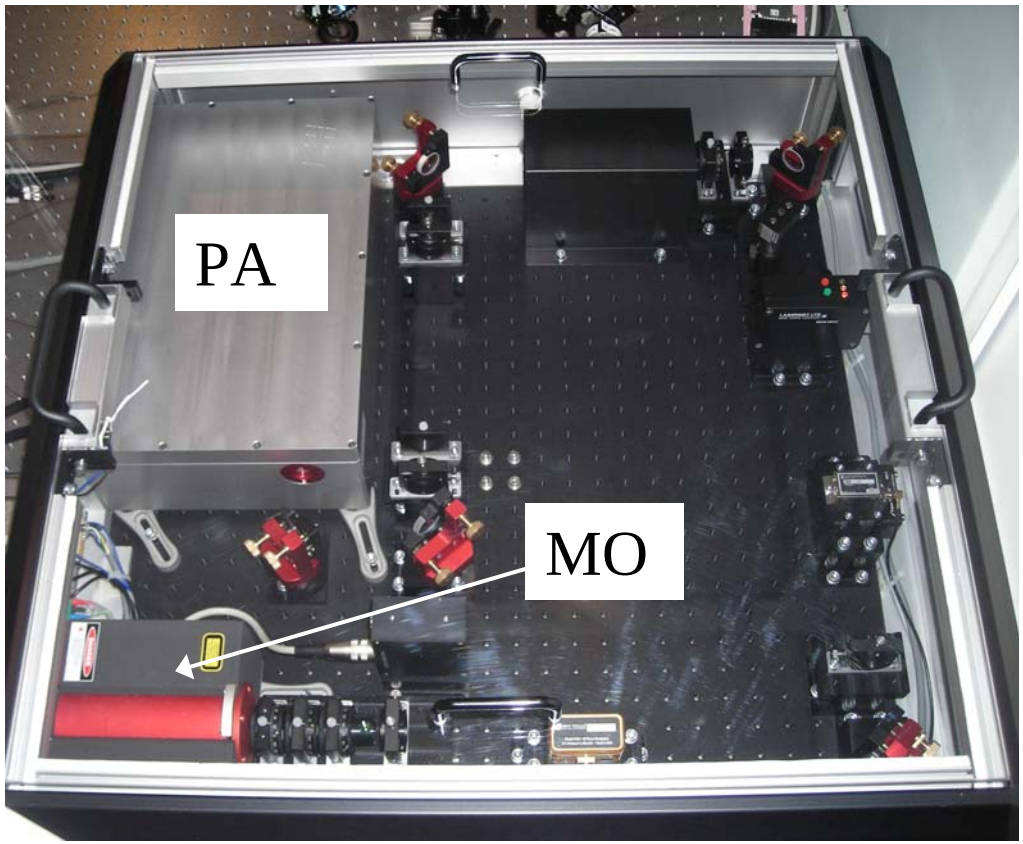
eLigo 35-W laser

- Built by Laser Zentrum Hannover in collaboration with AEI - Hannover
- Heart of the advLigo 200 W laser which is currently under development (preliminary design review this week)



Overview of LZH 35-W laser

- Built in a master-oscillator-power-amplifier (MOPA) configuration – similar to iLigo laser
- Uses 2-W Innolight non-planar ring oscillator (NPRO)
- Designed for integration into PSL
  - » Phase-correcting EOM between MO and PA
  - » AOM for power stabilization between MO and PA
- Four longitudinally-pumped, water-cooled amplifier heads
- Pump diodes (4 x 45 W) located remotely with fiber optic delivery to laser heads.



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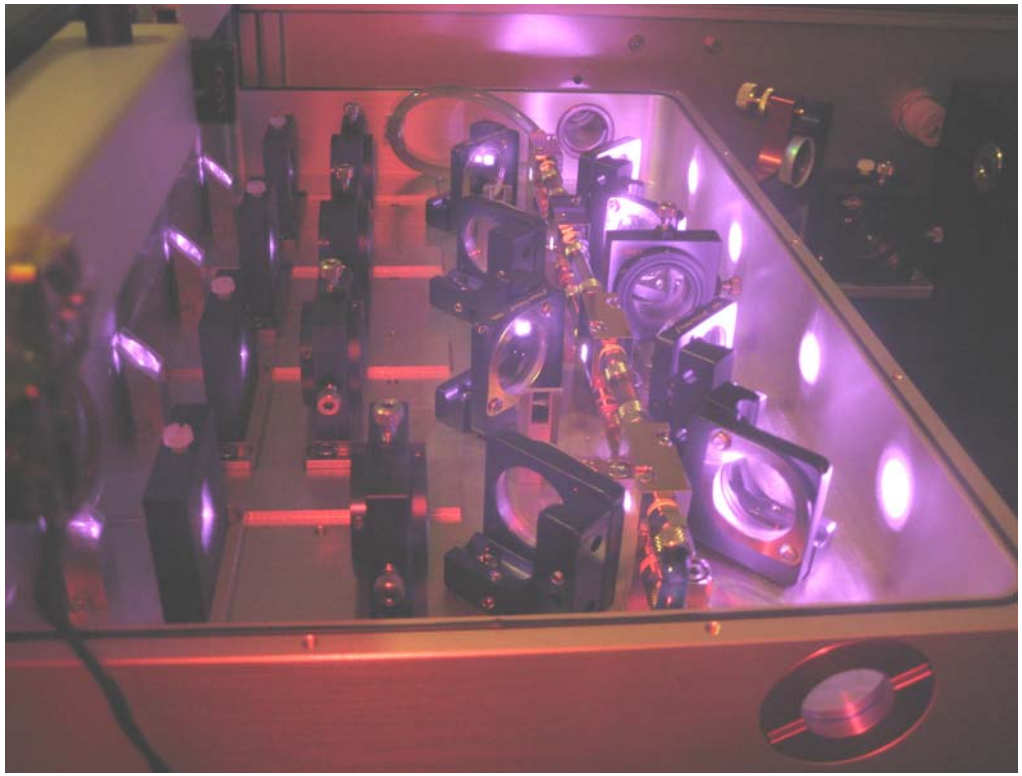

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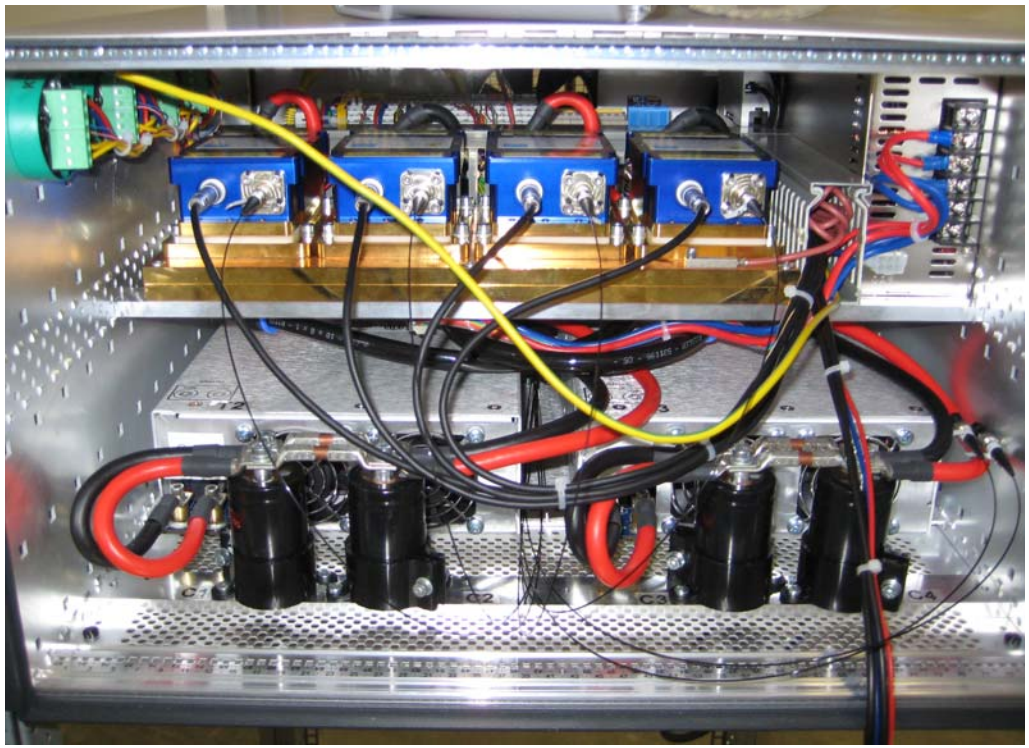
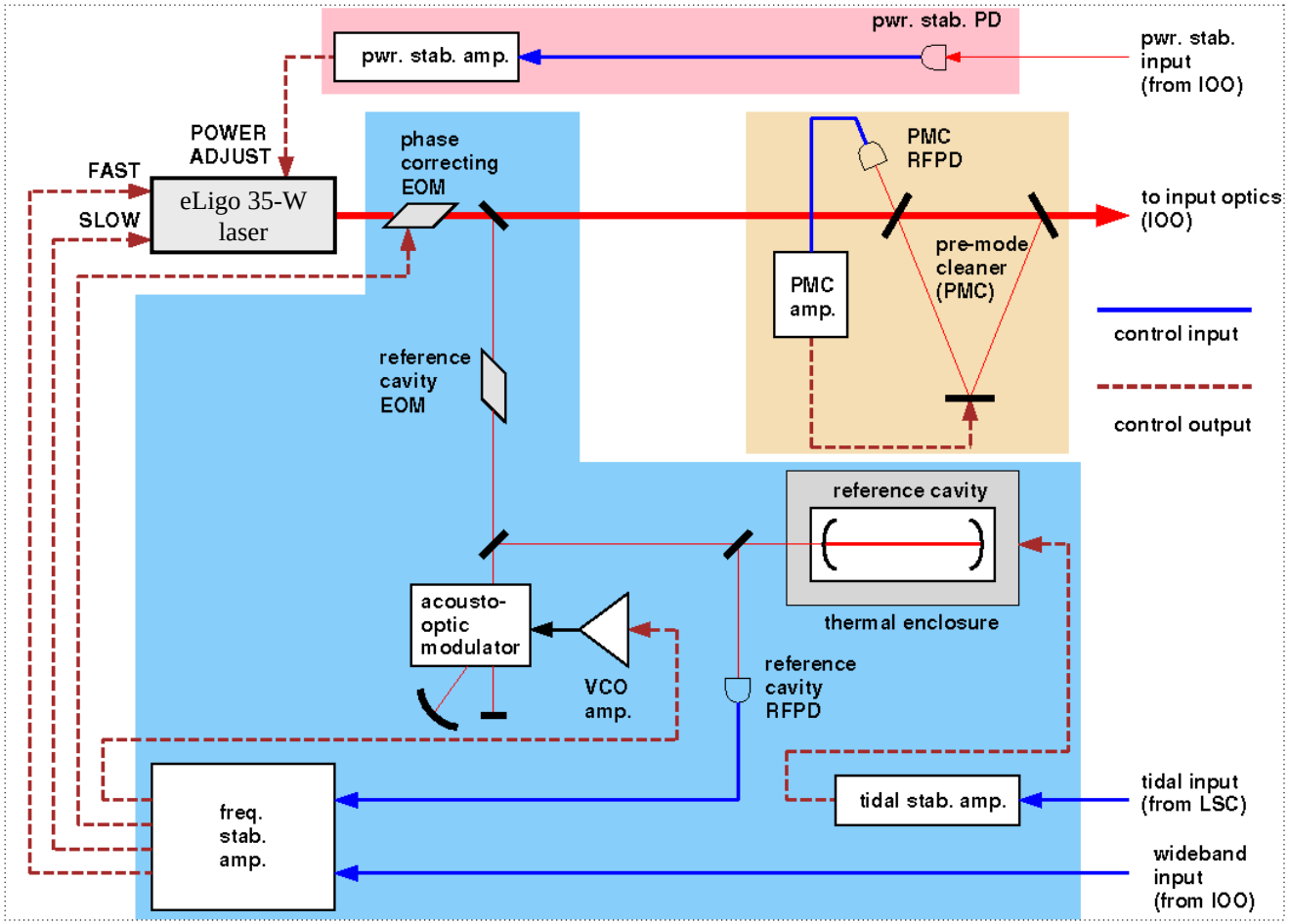


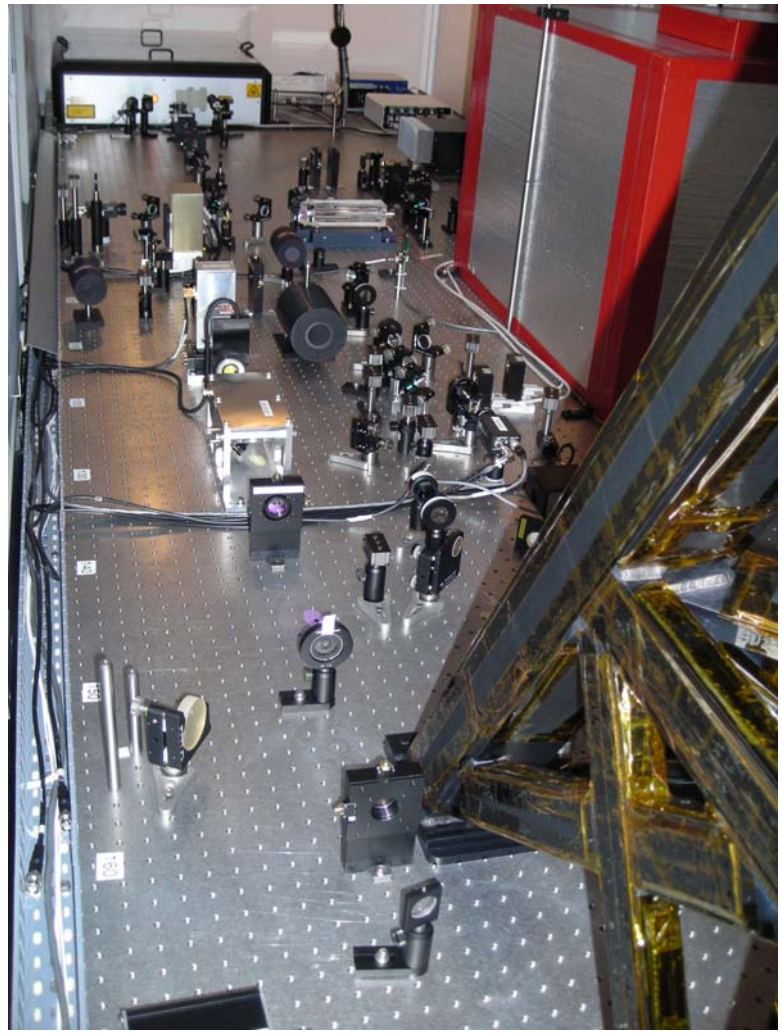
Integration into PSL

- Laser source
- Frequency pre-stabilization and actuator for further stab.
- Compensation for Earth tides
- Power stab. in GW band
- Power stab. at modulation freq. (~ 25 MHz)



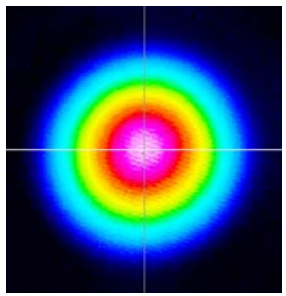
Observatory PSL upgrades

- LHO started March 24, 2008
  - » Installation complete
- LLO started July 28, 2008
  - » PSL installation complete (PMC running at 35 W)
  - » IO part delayed by Gustav. Scheduled for Oct. 21



eLigo PSL performace - PMC

- Using iLigo (S5) PMCs fabricated at LHO
- Circulating power ~ 600 kW/cm^2
- LHO visibility 95% at low power and at 35 W at high power
- LLO visibility 95% at low power.



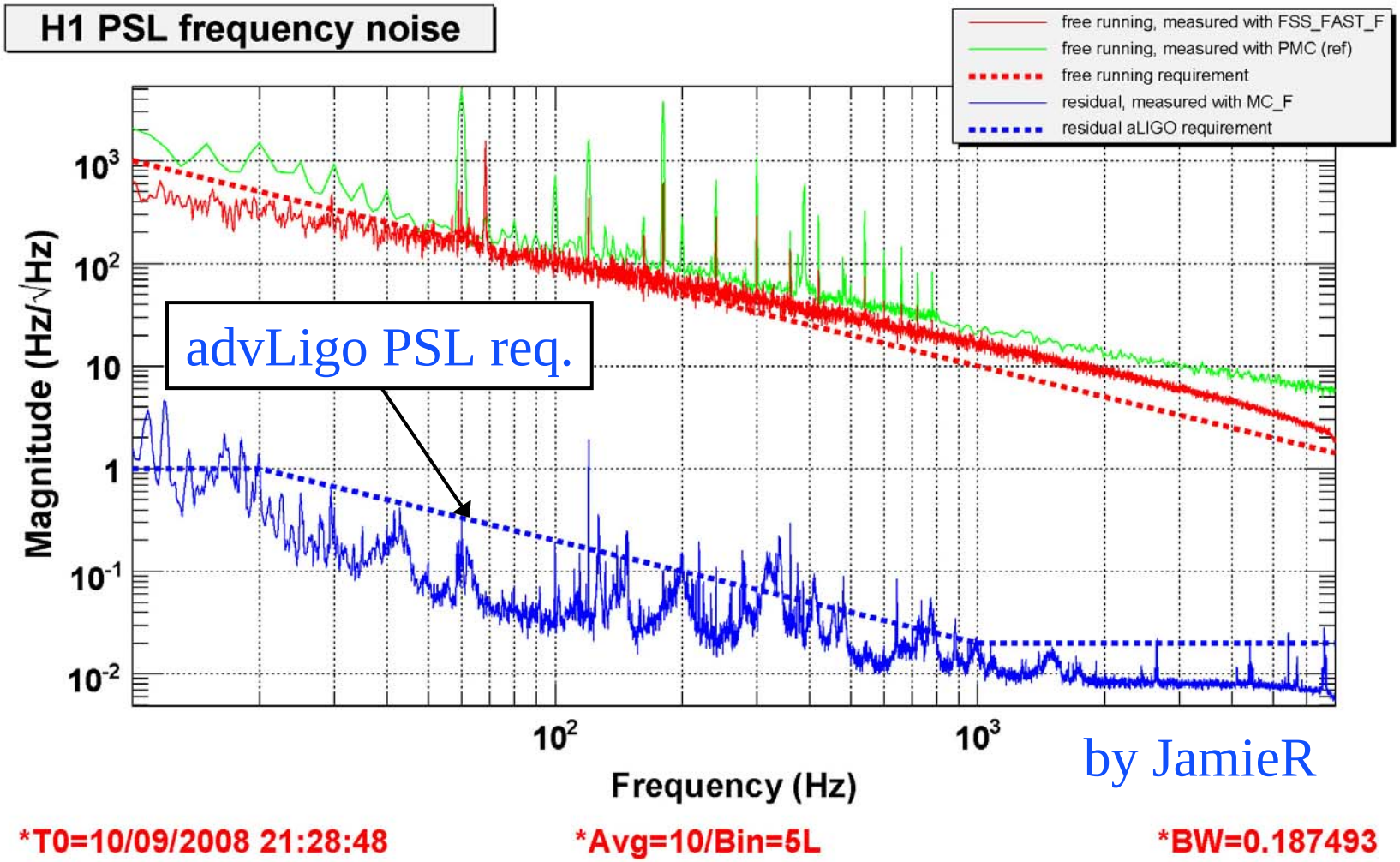
This indicates 35-W laser beam quality is very good.

But, LLO visibility degrades to 90% at 35 W.

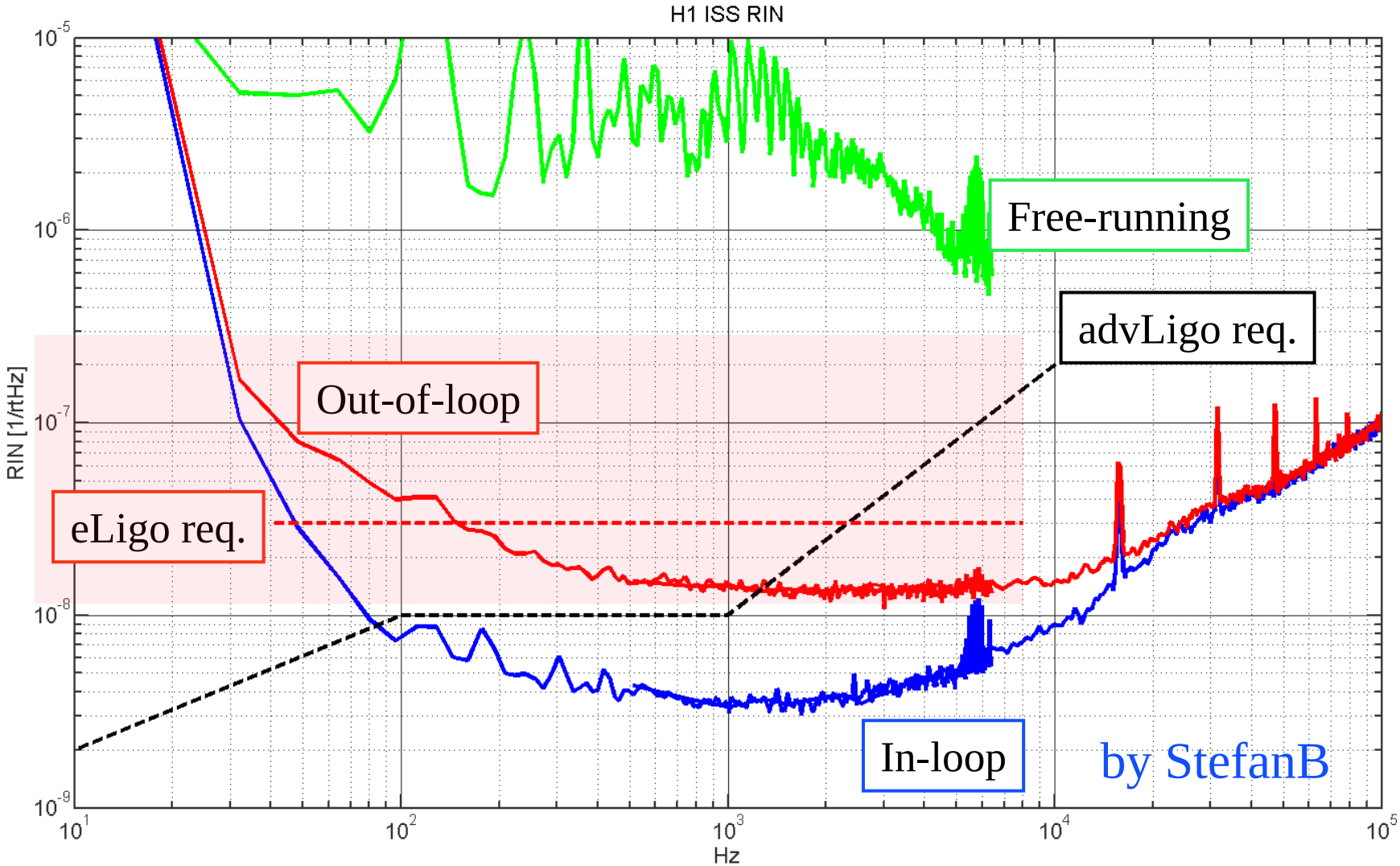
Contamination in PMC?

- We have one spare PMC
  - » may install at LLO in October
- M. Rakhmanov and students (UTB) have fabricated a second spare
  - » Plan to fabricate at least two more
- AEI group will build PMCs for advLigo

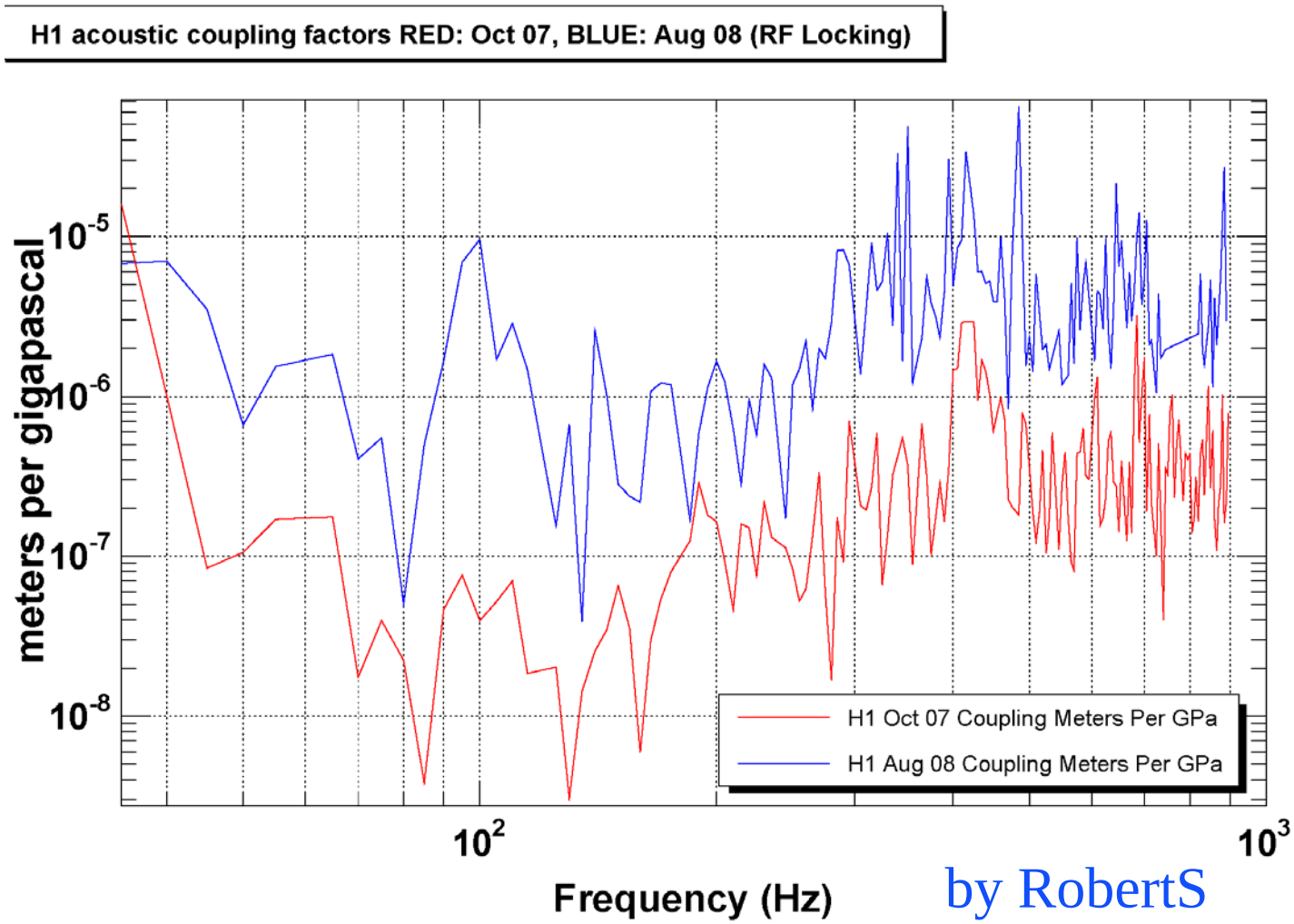
Frequency stabilization



Power stabilization

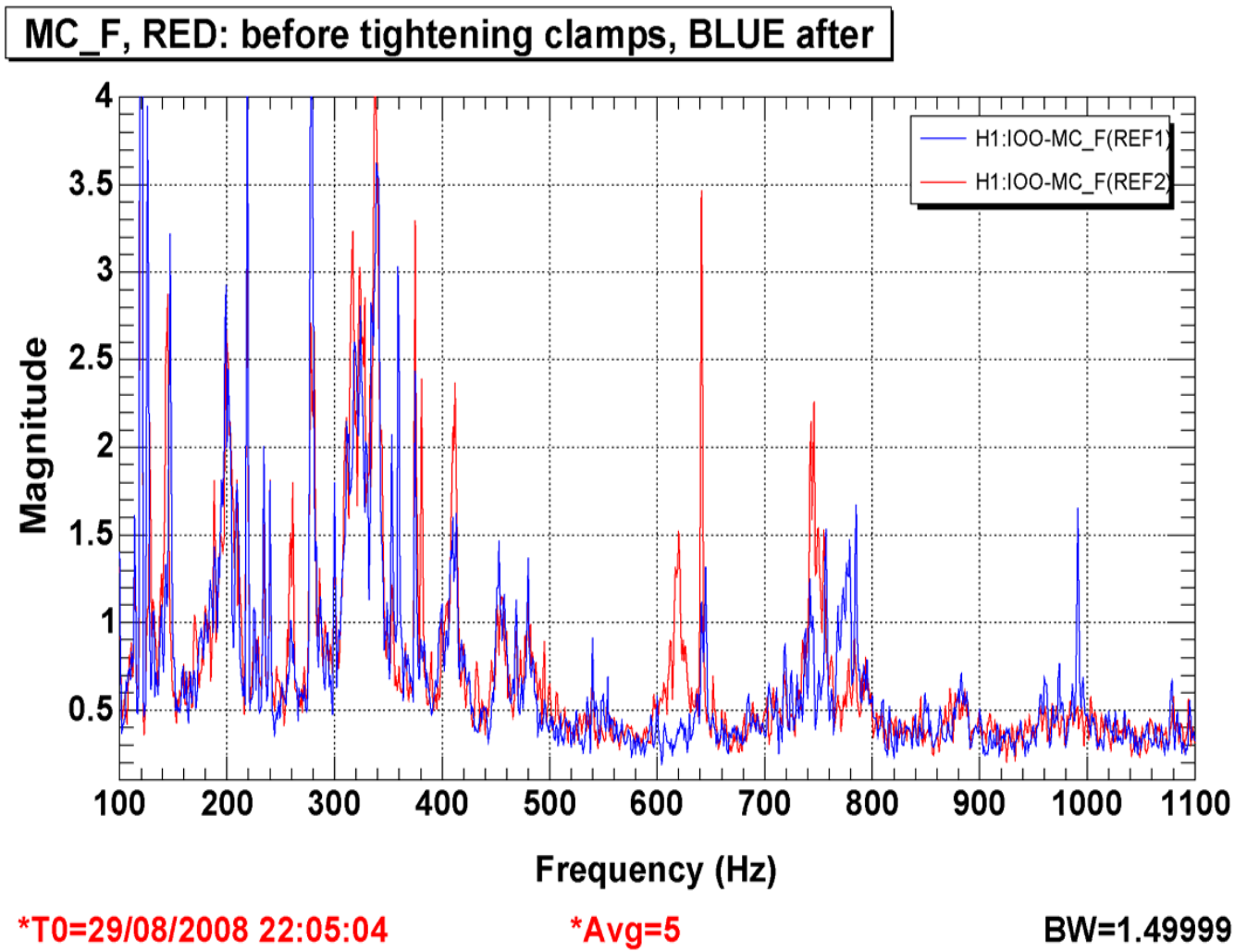


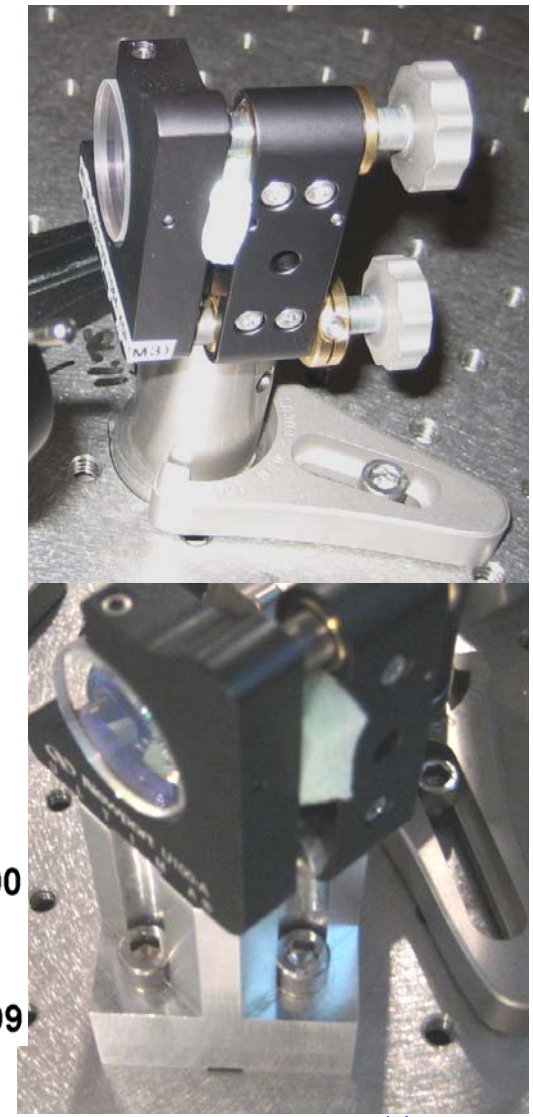
Acoustic noise coupling



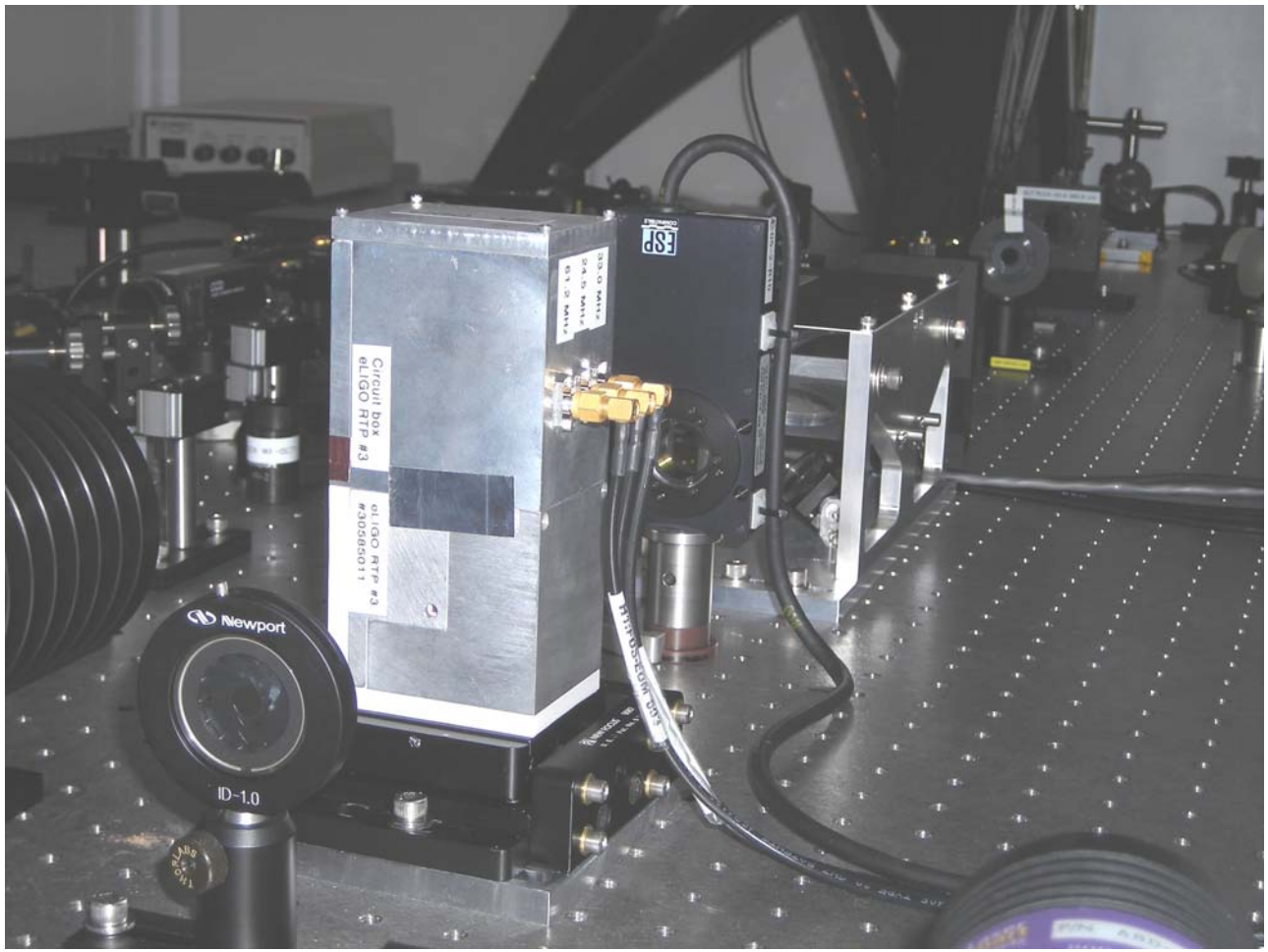
by RobertS

Noise coupling to MC control signal



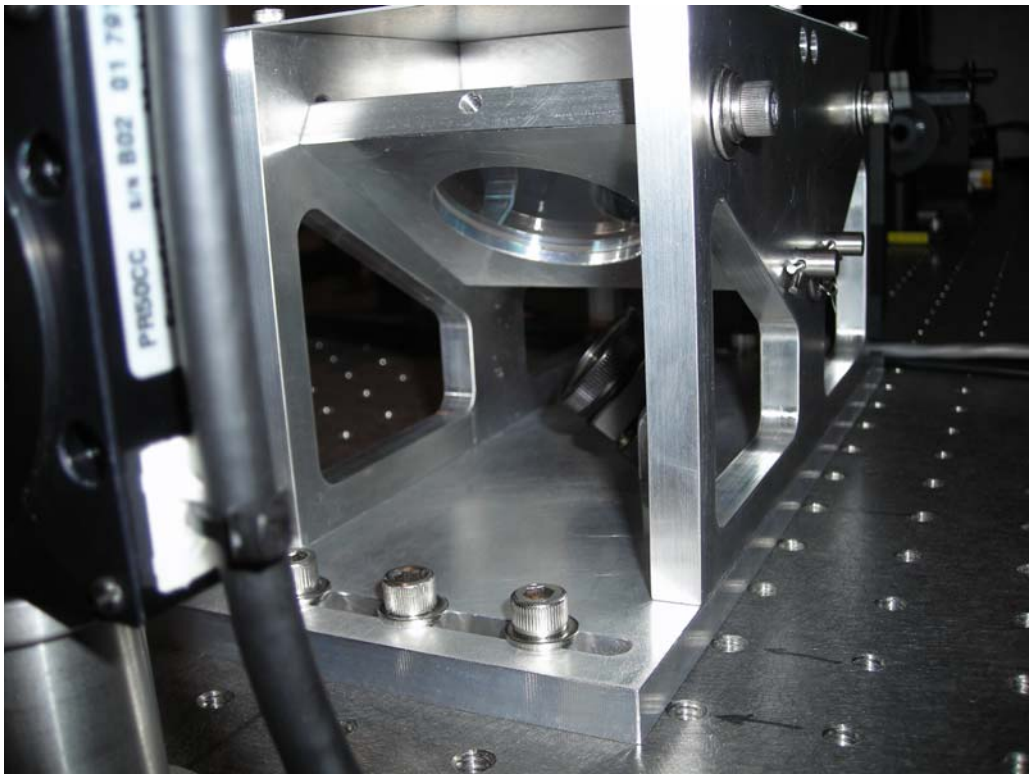


Input Optics (IO) upgrade



- High power (RTP), three-frequency EOM (VolkerQ's talk yesterday)
- Power control via half-wave plate and two thin-film polarizers
- Lenses for modematching to the modecleaner

IO upgrade - performance



Power control:

extinction ratio >140,000:1

transmission efficiency > 98%

Electro-optic modulator

No thermal lensing from EOM observed

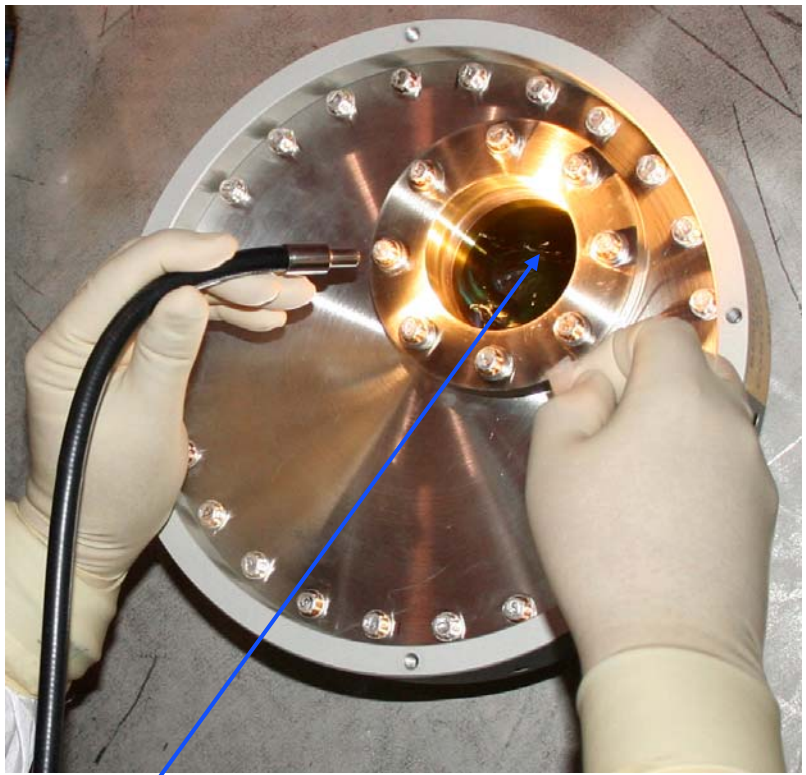
EOM running at full power for ~4 months

Modematching to modecleaner

H1 ifo. ~98% without optimizing lens positions

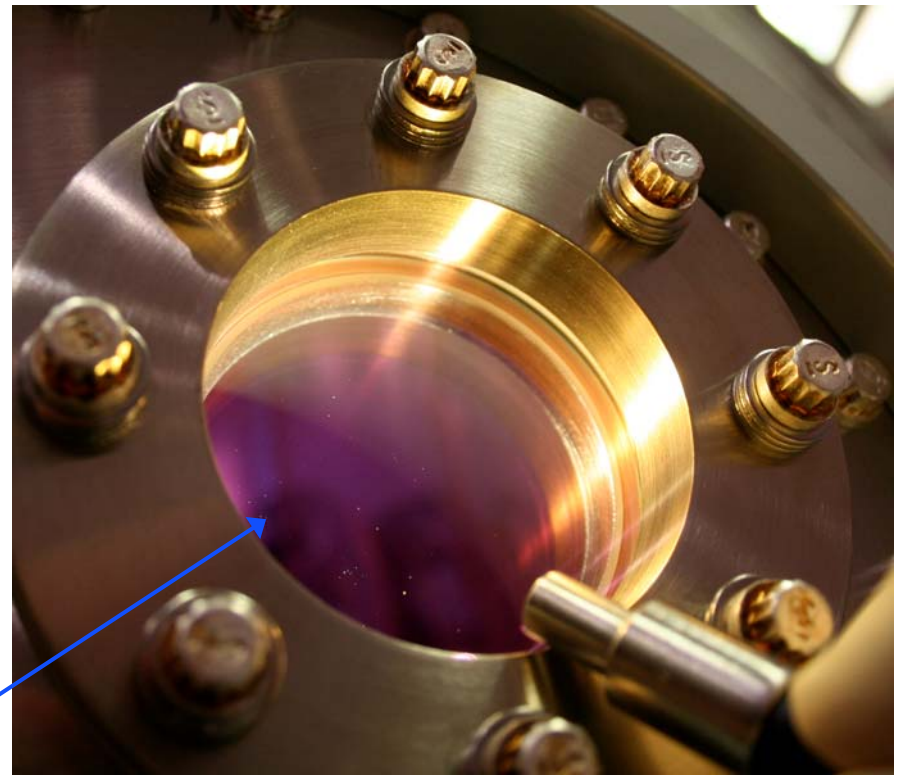
L1 in October

Transmission to modecleaner



Input beam location

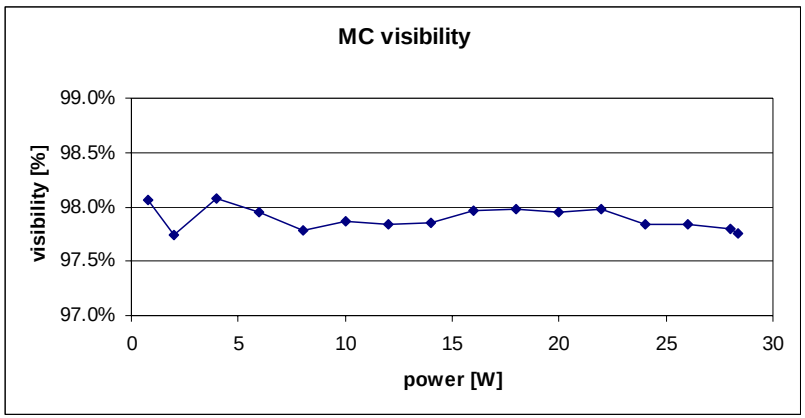
Cleaning and inspection of vacuum input window revealed contamination that could not be removed with standard cleaning (window not cleaned for 10 years!)



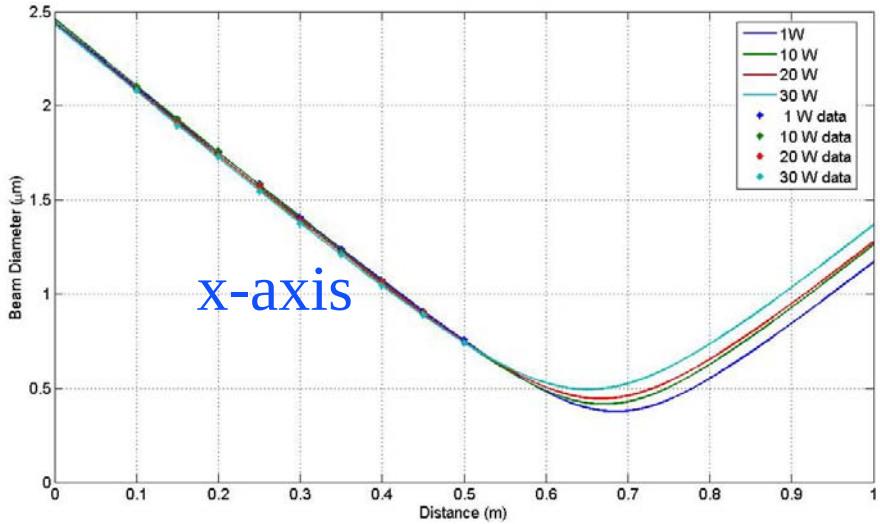
Window replaced last week

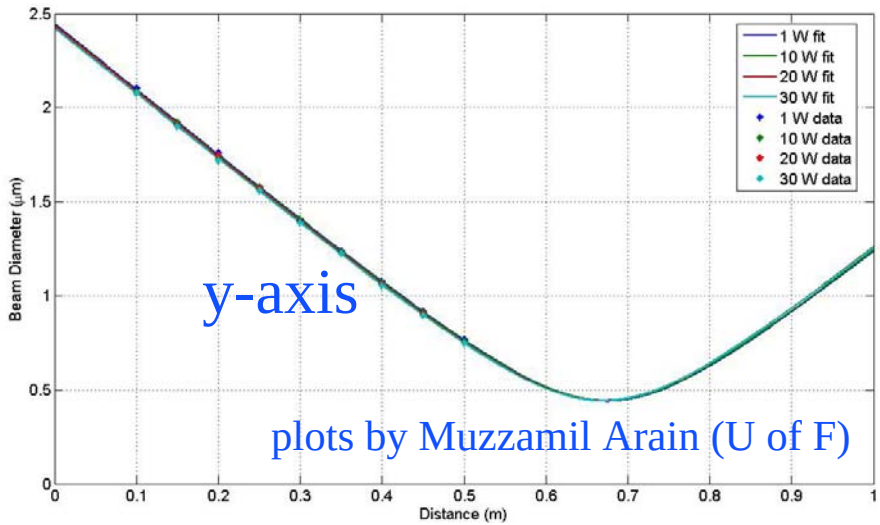
Thermal effects in MC?

- Operated H1 MC at increasing power levels up to 28 W
  (VolkerQ, KeitaK, NicS, RickS)
- Looked for indications of thermal effects in MC
  - » Input: visibility
  - » Output: beam profile scans



- Preliminary indication is that thermal effects appear to be much smaller than feared. (good news!)





plots by Muzzamil Arain (U of F)