Upgrade of Thermal Compensation System for Enhanced LIGO

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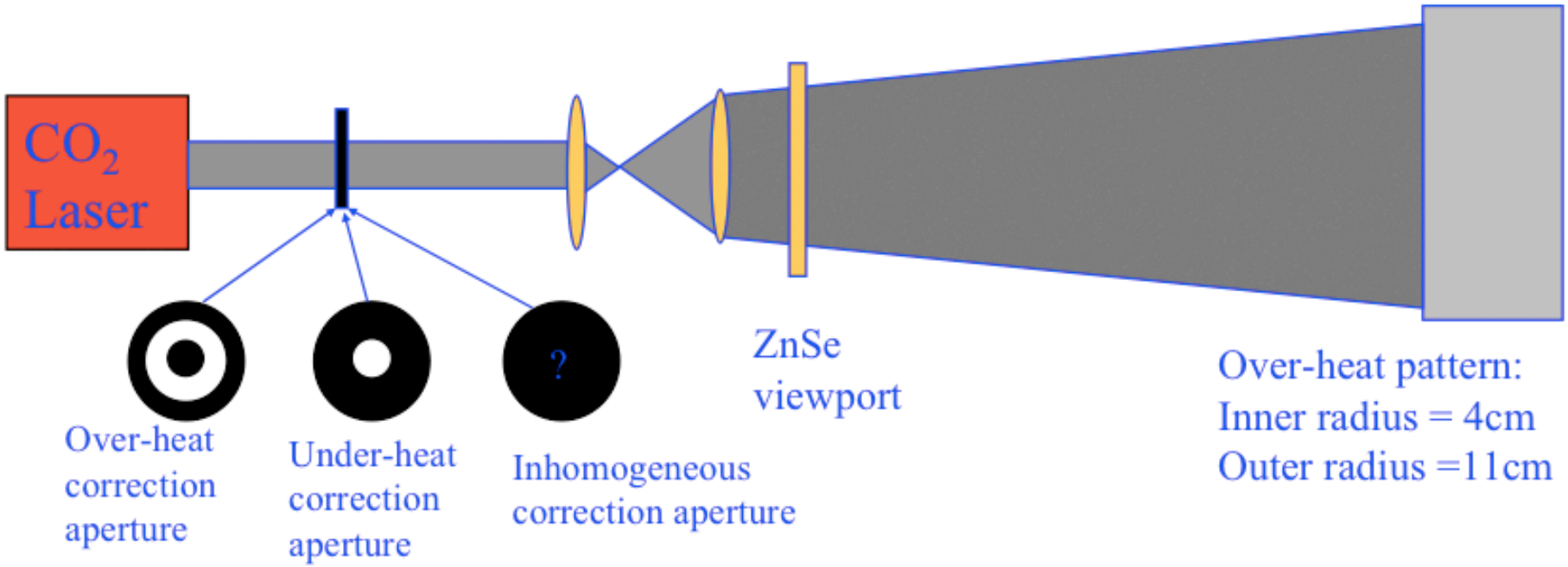
Main laser beam creates thermal distortions in optics

- Main thermal effects are thermoelastic deformation, thermal lensing
- Create wavefront distortions that decrease gravitational wave strain sensitivity
- Optics designed to operate with a certain amount of thermal lensing based on absorption, laser power
- Absorption of mirrors difficult to predict
- Thermal compensation required to achieve level of heating for correct radius of curvature

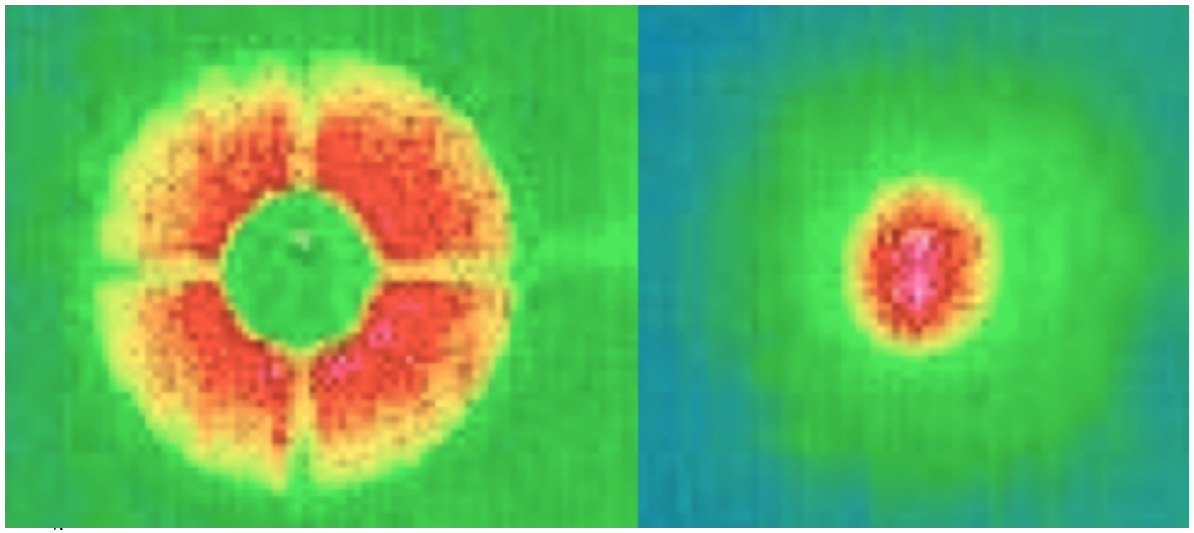
Thermal Compensation System

- **Remotely heat optic**
- **Annular or central heating pattern**



Current heating pattern at LIGO sites

	H1	H2	L1
ITMX	Central	None	Annular
ITMY	Central	Annular	Central

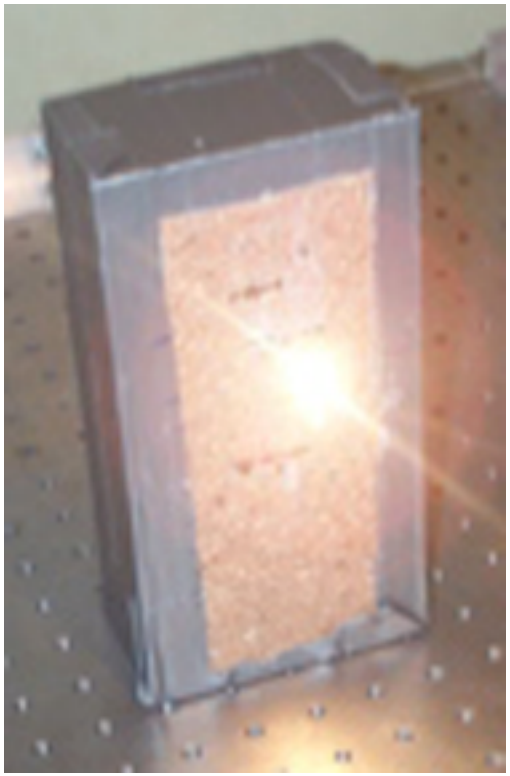


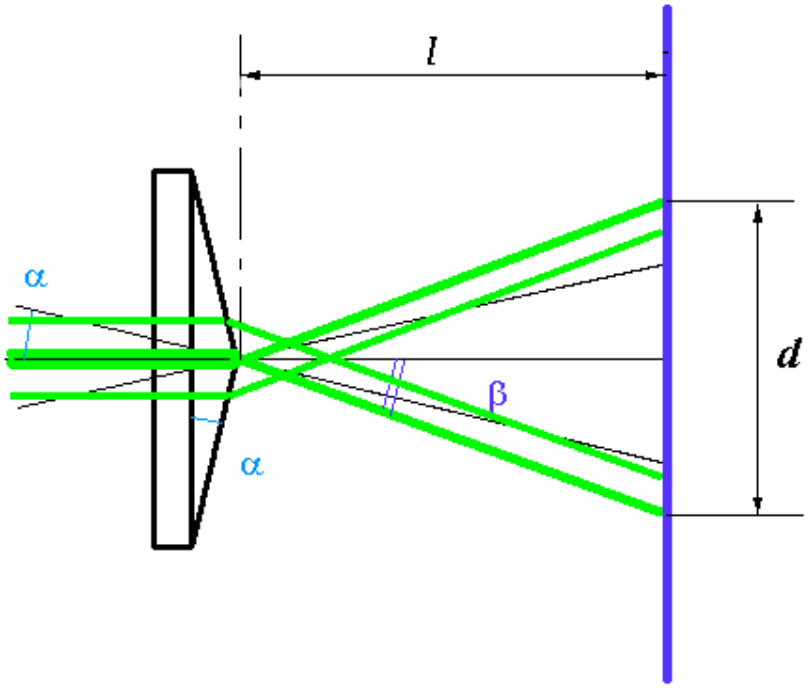
LIGO upgrades will require more TCS power

- **Laser input power will increase from 7 W to about 35 W for Enhanced LIGO**
- **Power circulating in cavities will increase from 15 kW to about 64-80 kW for eLIGO**
- **Increased heating requires more thermal compensation power**
- **All optics will require annular heating**

TCS Upgrade Plans

- Increase power from 10 W to 35 W
- Replace annular mask with conical optics



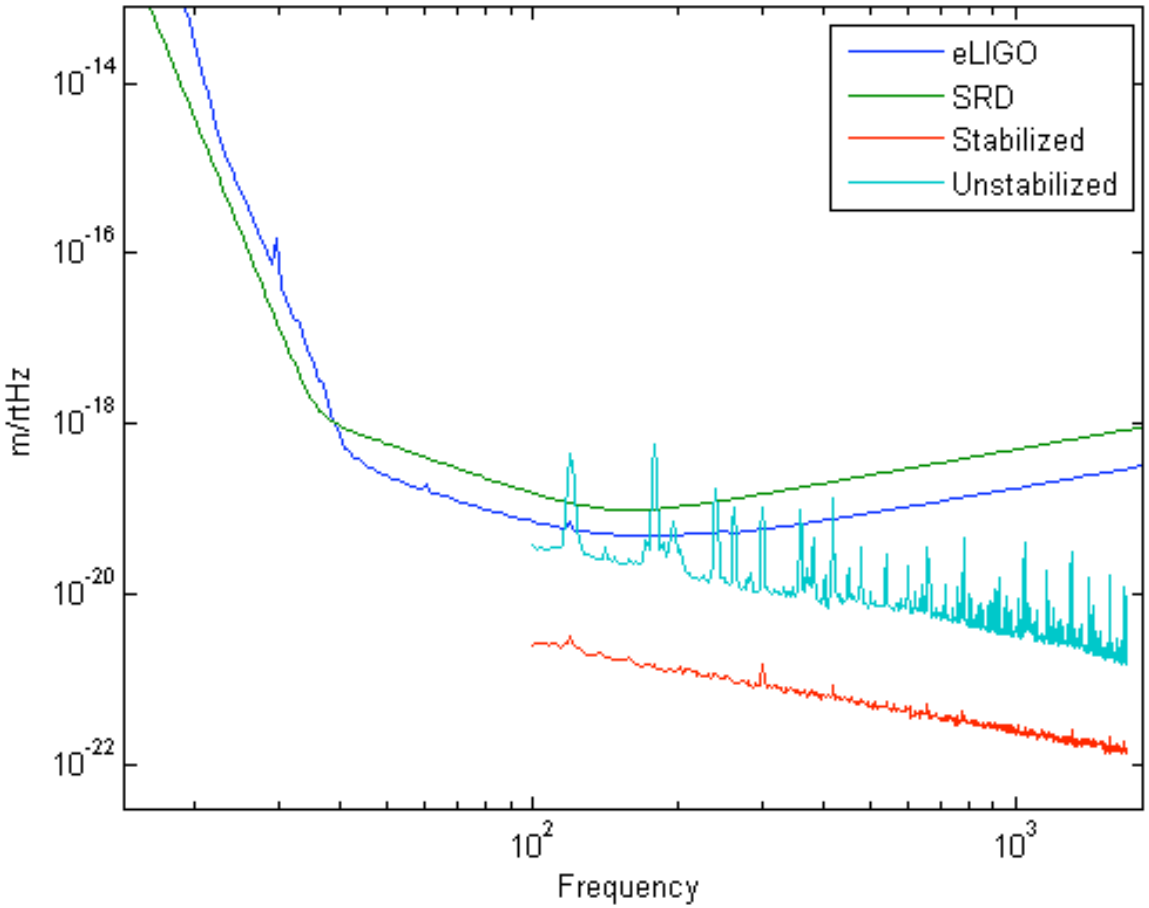


http://www.wavelength-tech.com

Intensity noise couples to interferometer noise

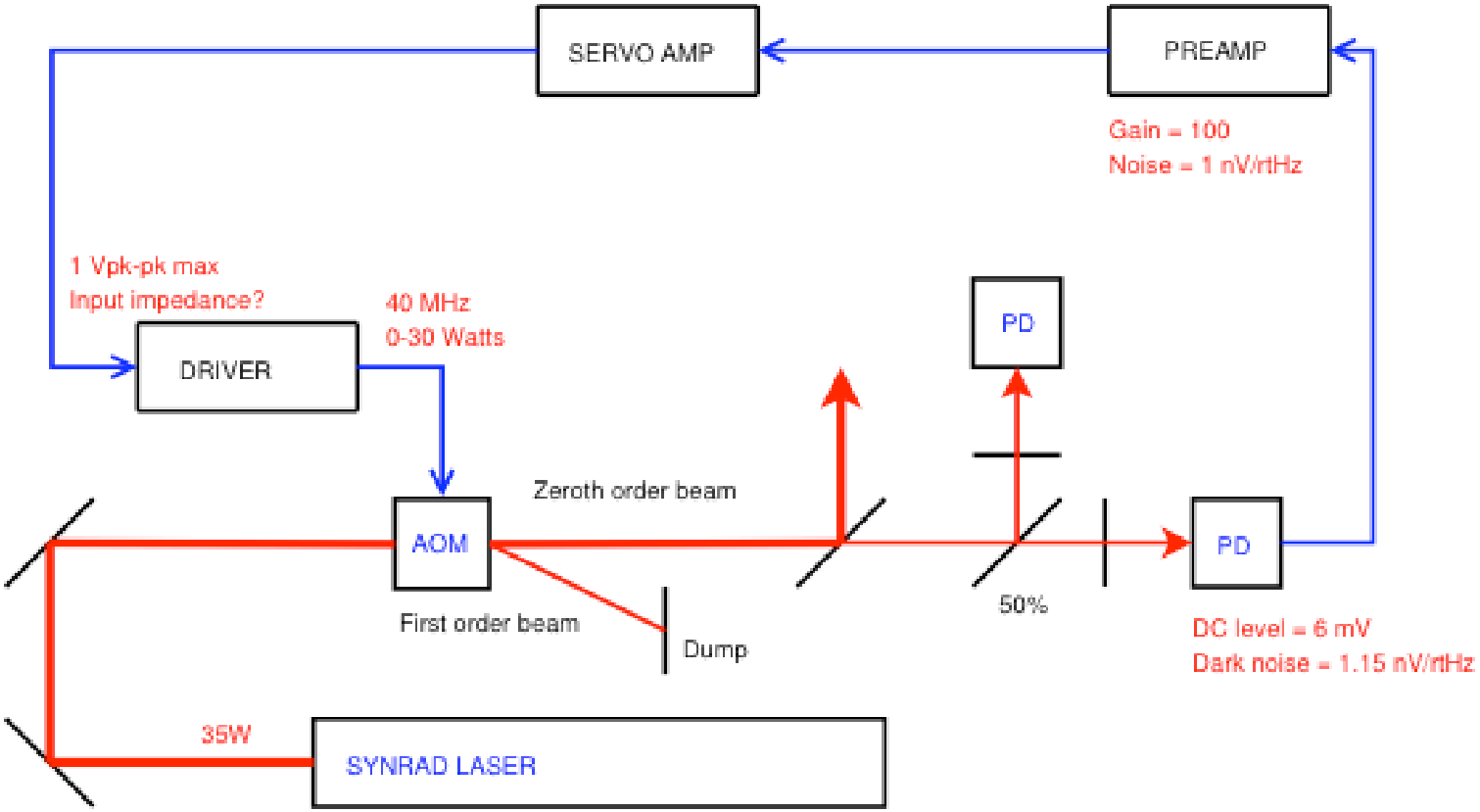
- Intensity fluctuations in CO2 laser causes temperature fluctuations on optic which convert to displacement noise
  - » Expansion of optic
  - » Change of index of refraction
  - » Bending of optic
- Radiation pressure also causes noise

Intensity noise couples to interferometer noise

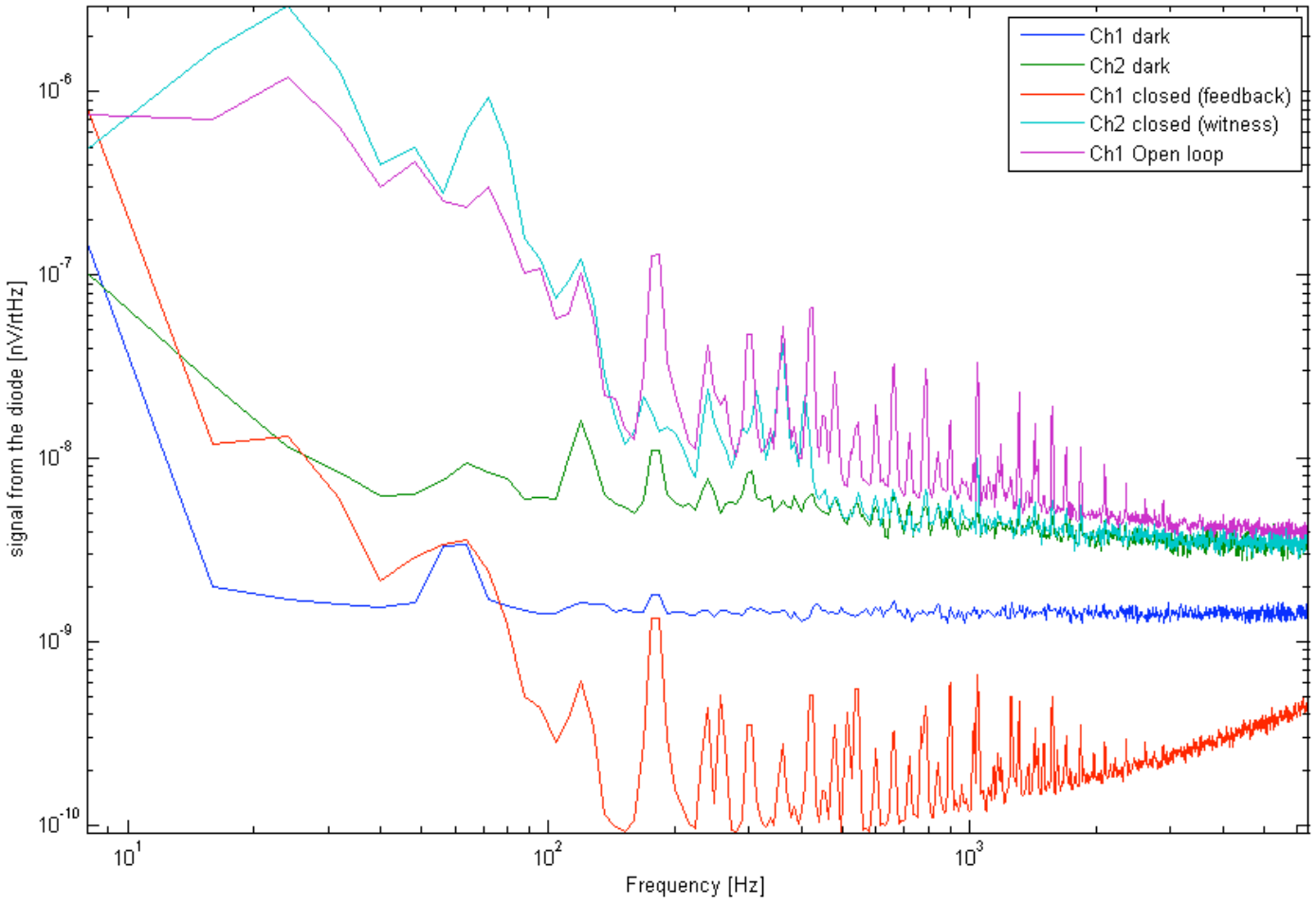


$$< \Delta z >= 1.4 \times 10^{-17} m \left(\frac{150Hz}{f} \right) \left(\frac{P}{1mWatt} \right) RIN$$

Increased laser power requires intensity stabilization



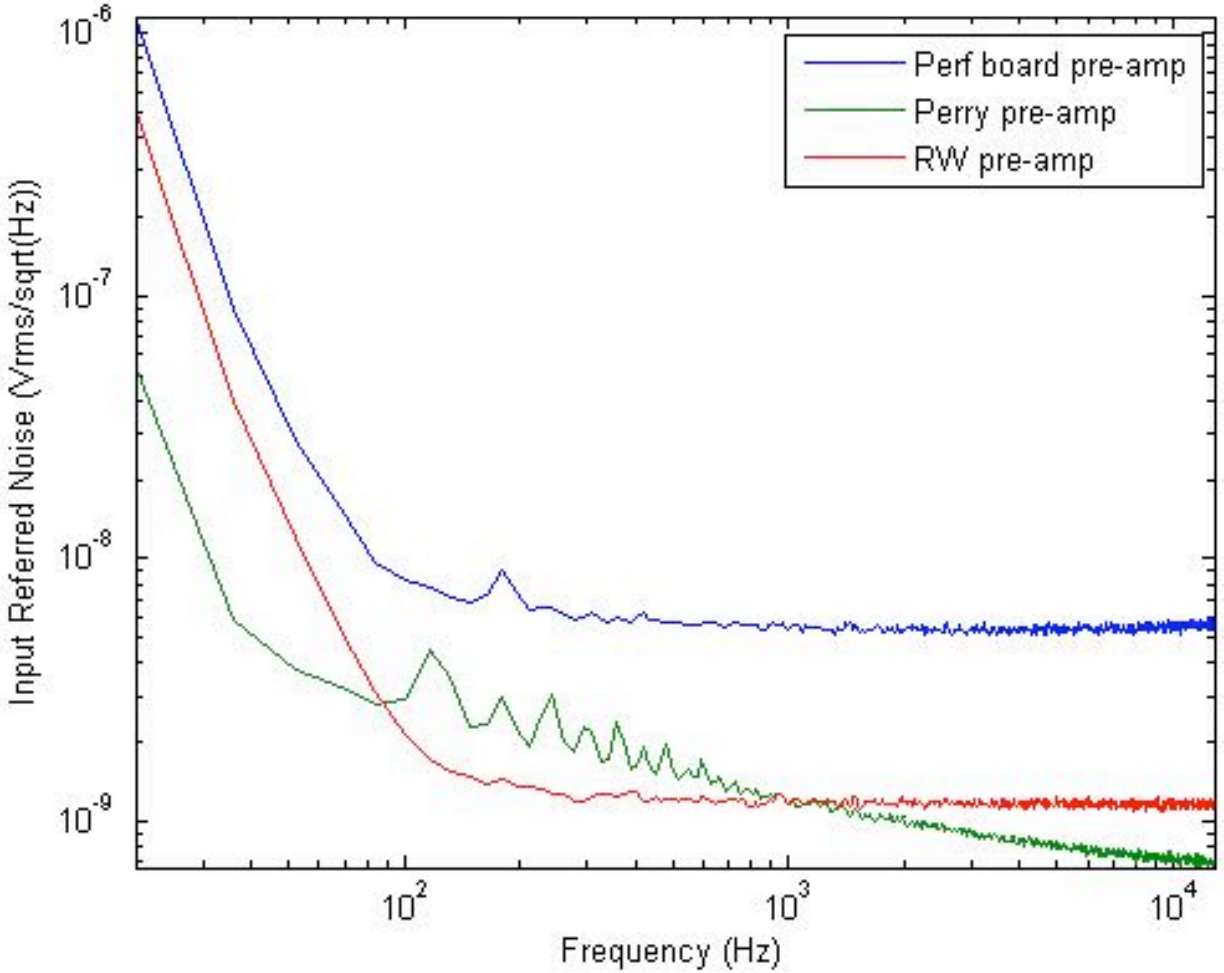
Increased laser power requires intensity stabilization



Noise hunting

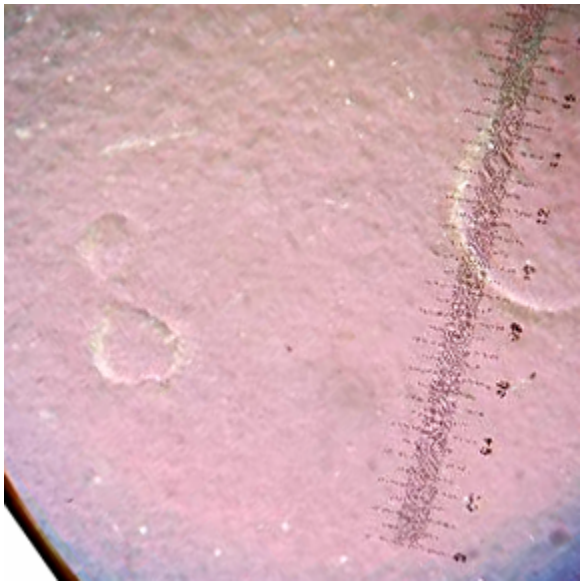
- Stabilize photodiode mounts, laser mount
- Make low-noise preamplifiers
  - » Changed from battery to power supply
  - » Thin-film resistors
- Determine photodiode structure

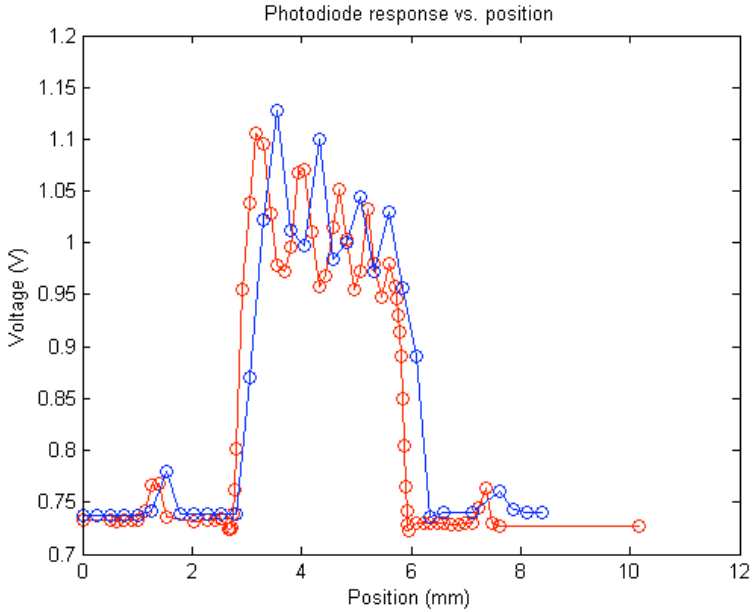
Preamplifier Noise Spectra



Photodiode structure may contribute to sensor noise

- Inhomogeneity in photodiode sensitivity will create noise if beam is moving
- Examination with microscope shows no visible structure
- Measuring voltage vs. position shows peaks in response
- Automated scanner will measure response over surface





Future Plans

- **Stabilize intensity to acceptable level**
- **Set up conical lenses to create annular heating shape**
- **Plan to upgrade at sites in early 2008**