Tests of BNL Laser Vibrometer
and
Status of RHIC Quad Measurements

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Introduction

- Preparations are actively underway to carry out vibration measurements in a RHIC quadrupole using a dual beam laser Doppler vibrometer.
- Two fixtures were designed and built to mount the fiber-optic laser heads on the cold test stand for measuring horizontal and vertical motion.

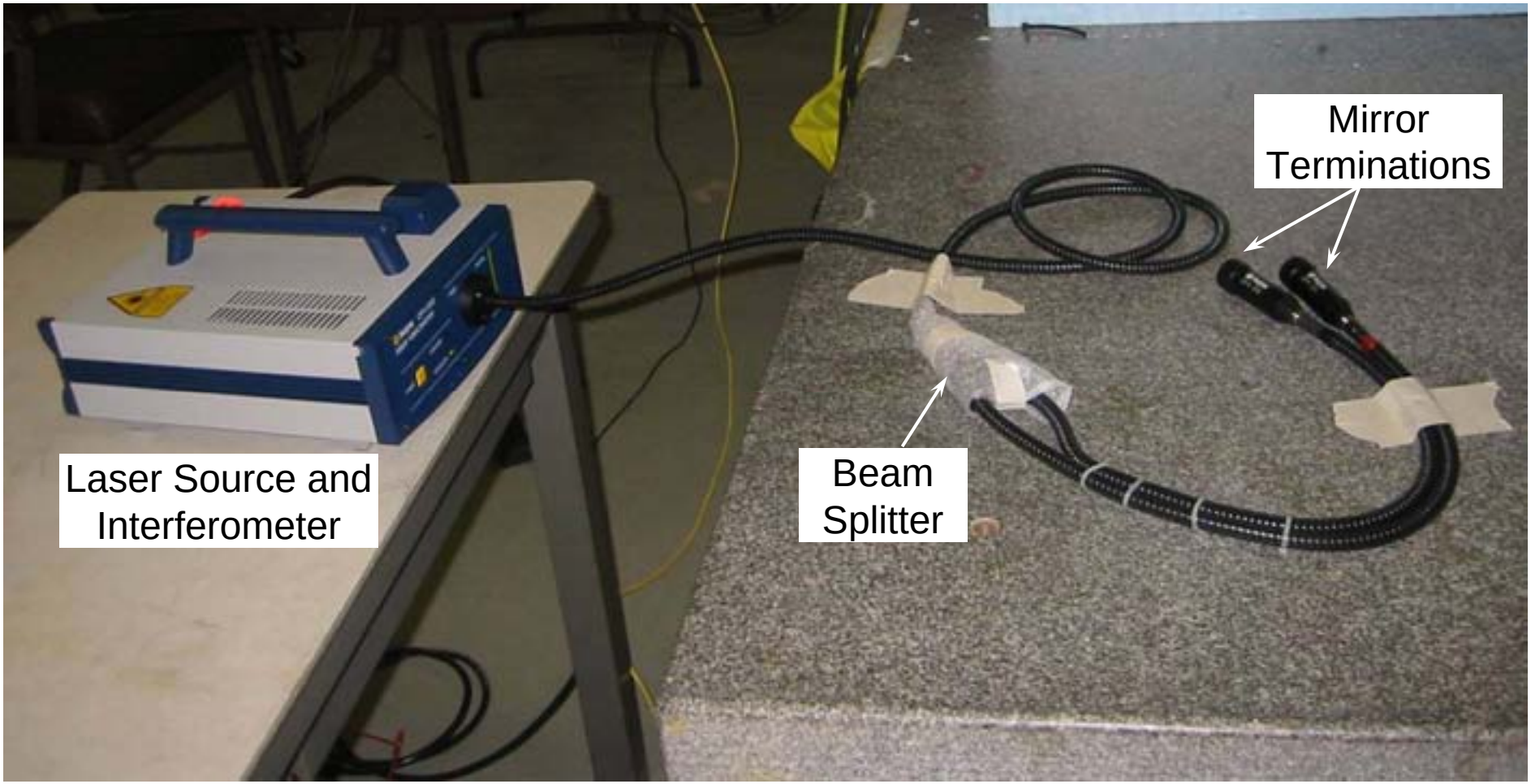
Delivery of the Laser System

- The system purchased is a dual fiber-optic head Doppler vibrometer, PolyTec Model OFV-552 along with OFV-5000 controller, a VD-06 digital velocity decoder, and a LF-02 adaptive filter module.

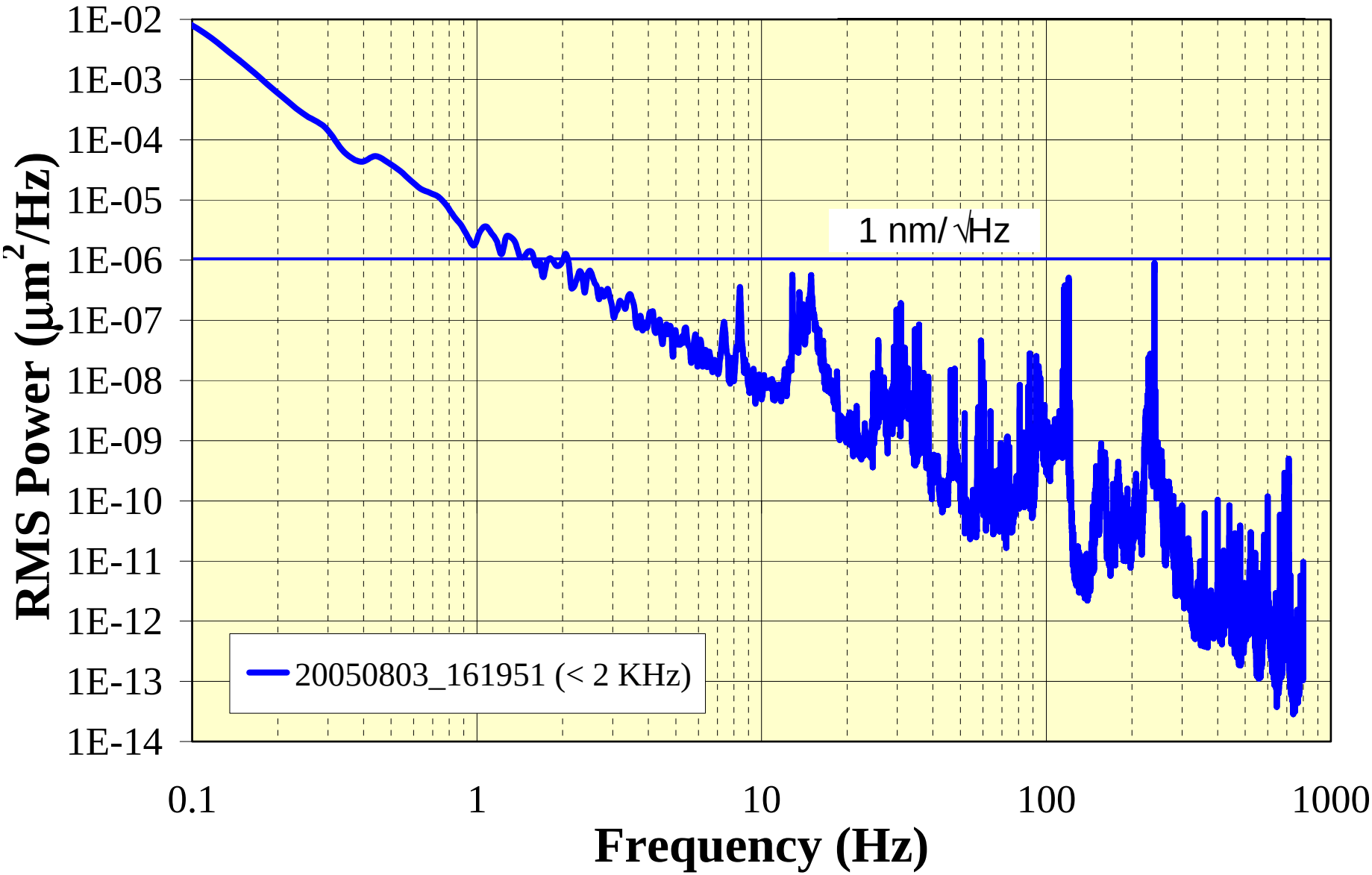
Laser Performance Tests: Intrinsic Noise

- We measured the intrinsic noise of the system by terminating both arms of the laser head with mirrors.
- This is not a fool-proof test of the intrinsic noise, because the mirrors could still have some internal motion of their own. Similarly, the fibers themselves are somewhat sensitive to acoustic pick up.
- In the absence of a perfectly stable laser holder, and a perfectly stable target to look at, terminating both fibers perhaps comes as close to intrinsic noise as possible.
- All measurements were done in the velocity mode, 1 mm/s per Volt range, and 5 kHz low pass filter programmed into the laser controller. An amplifier was used to further boost the signal output (typically 200X).

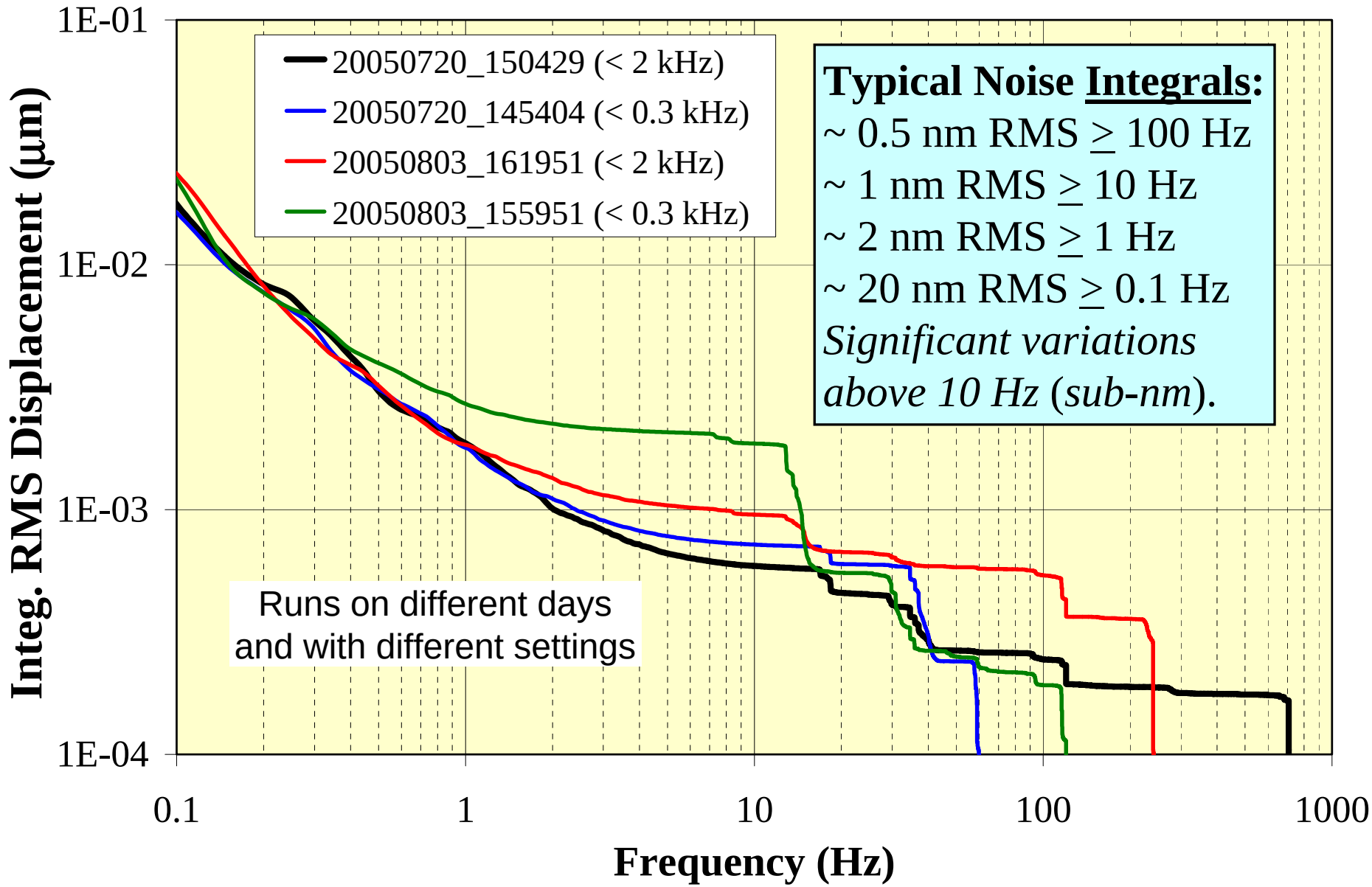
Dual Mirror Setup for Noise Tests



Power Spectrum with Both Beams Terminated



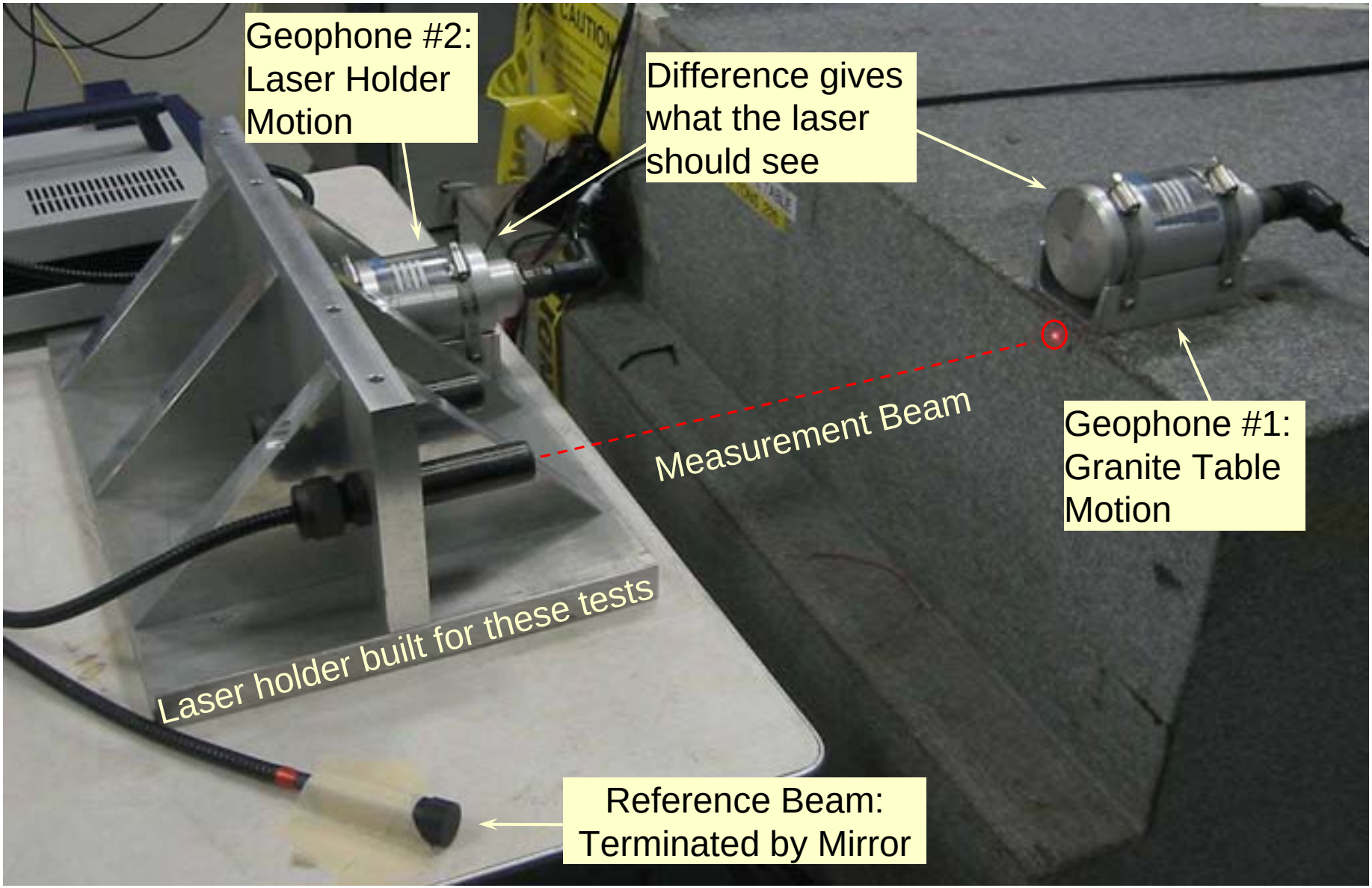
Laser Vibrometer: Both Beams Terminated by Mirrors



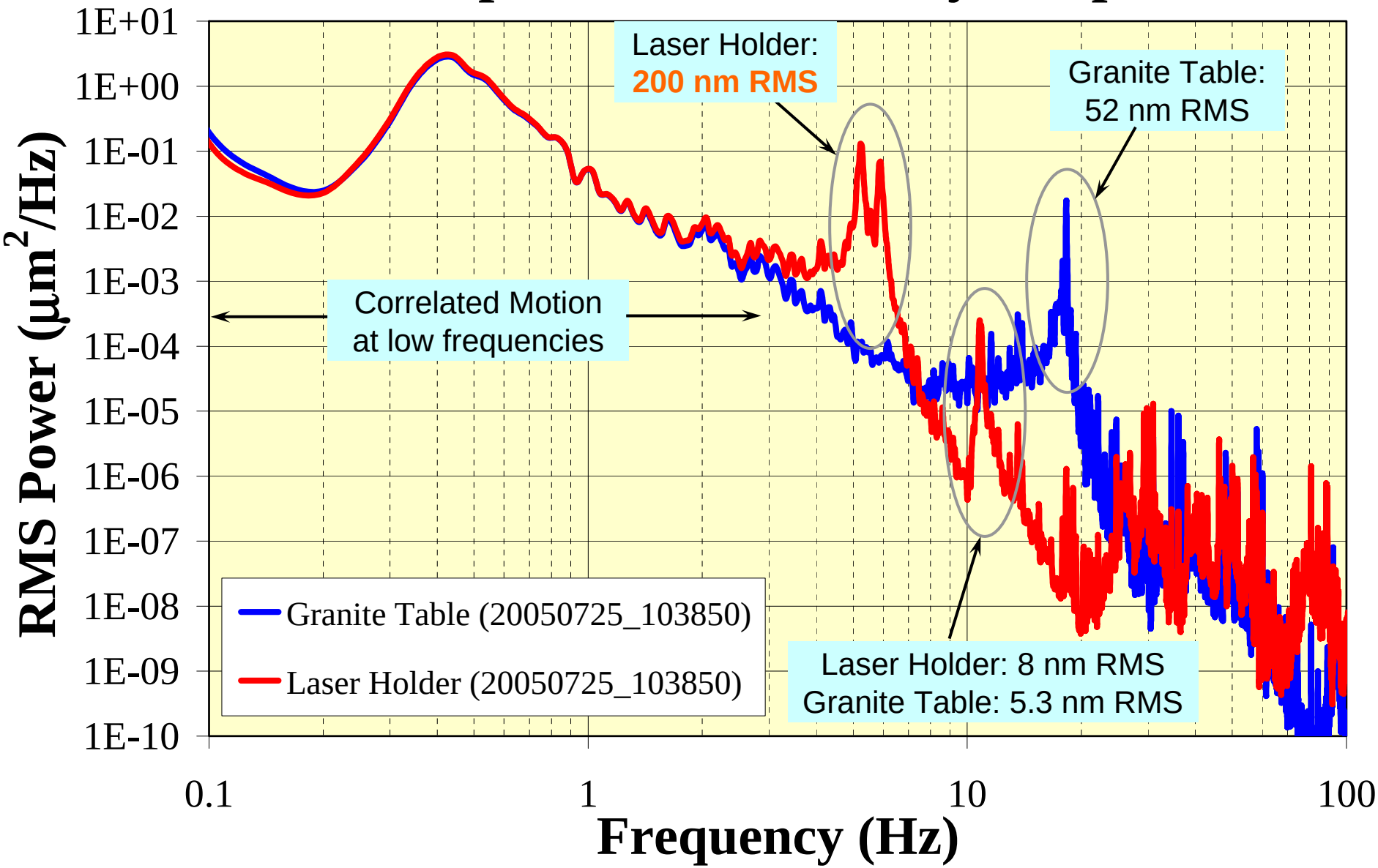
System Performance: “Real Life” Situations

- It is desirable to obtain a measure of the system performance under typical measurement conditions.
- As opposed to “noise measurements” this does not require an absolutely stable object, or a holder. One only needs an independent knowledge of the motion of the object and the holder (could be provided by geophones).
- One can evaluate the performance of the laser system in both the single beam (= relative motion of laser holder and object) and the dual beam (= relative motion of two objects) modes.
- We used the side of a 7 ton granite table as the object, with the laser holder placed on an ordinary wooden table.
- Geophone data were compared to the laser system data.

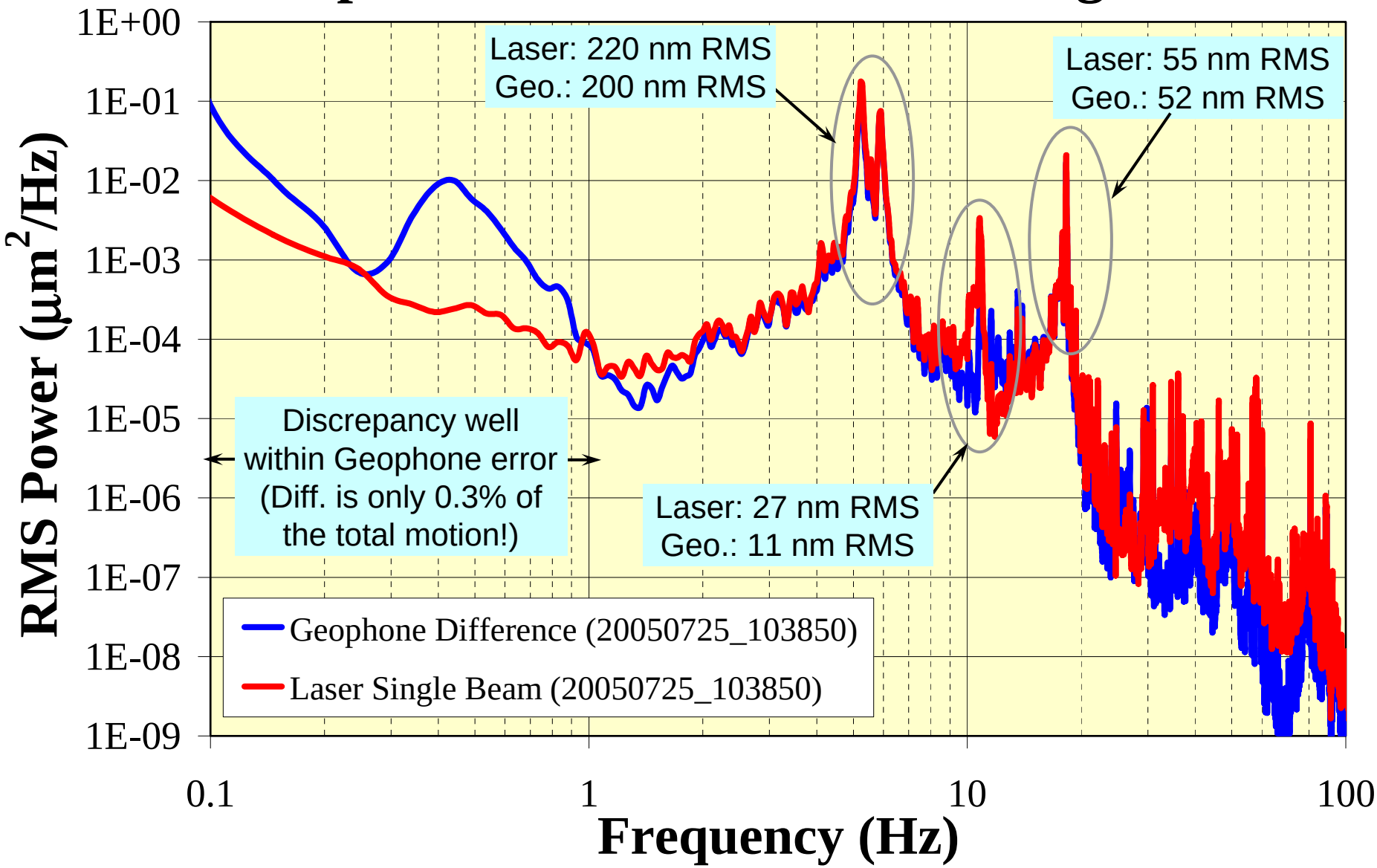
Performance Tests: Single Beam Mode



Power Spectra Measured by Geophones



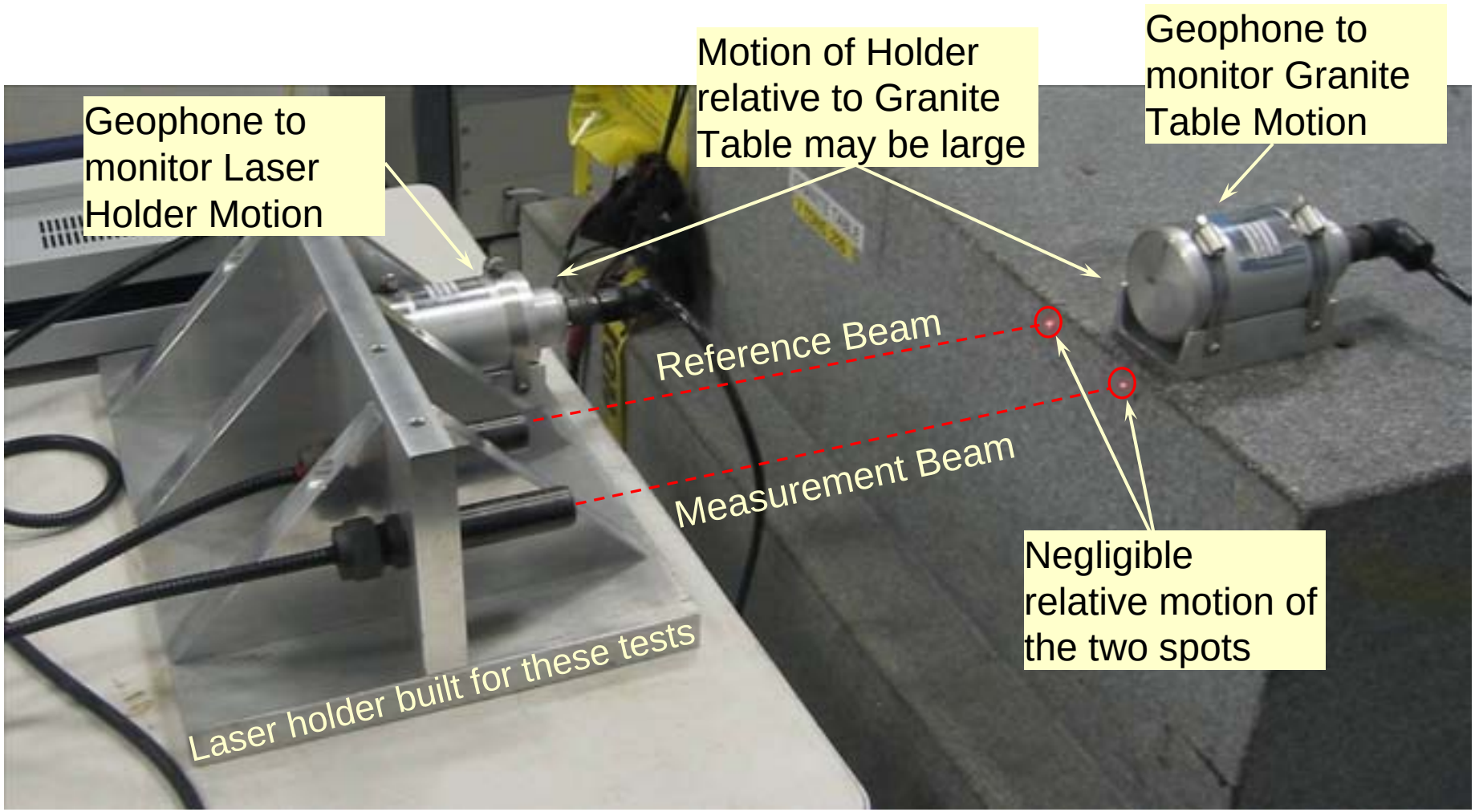
Geophone Difference & Laser Single Beam



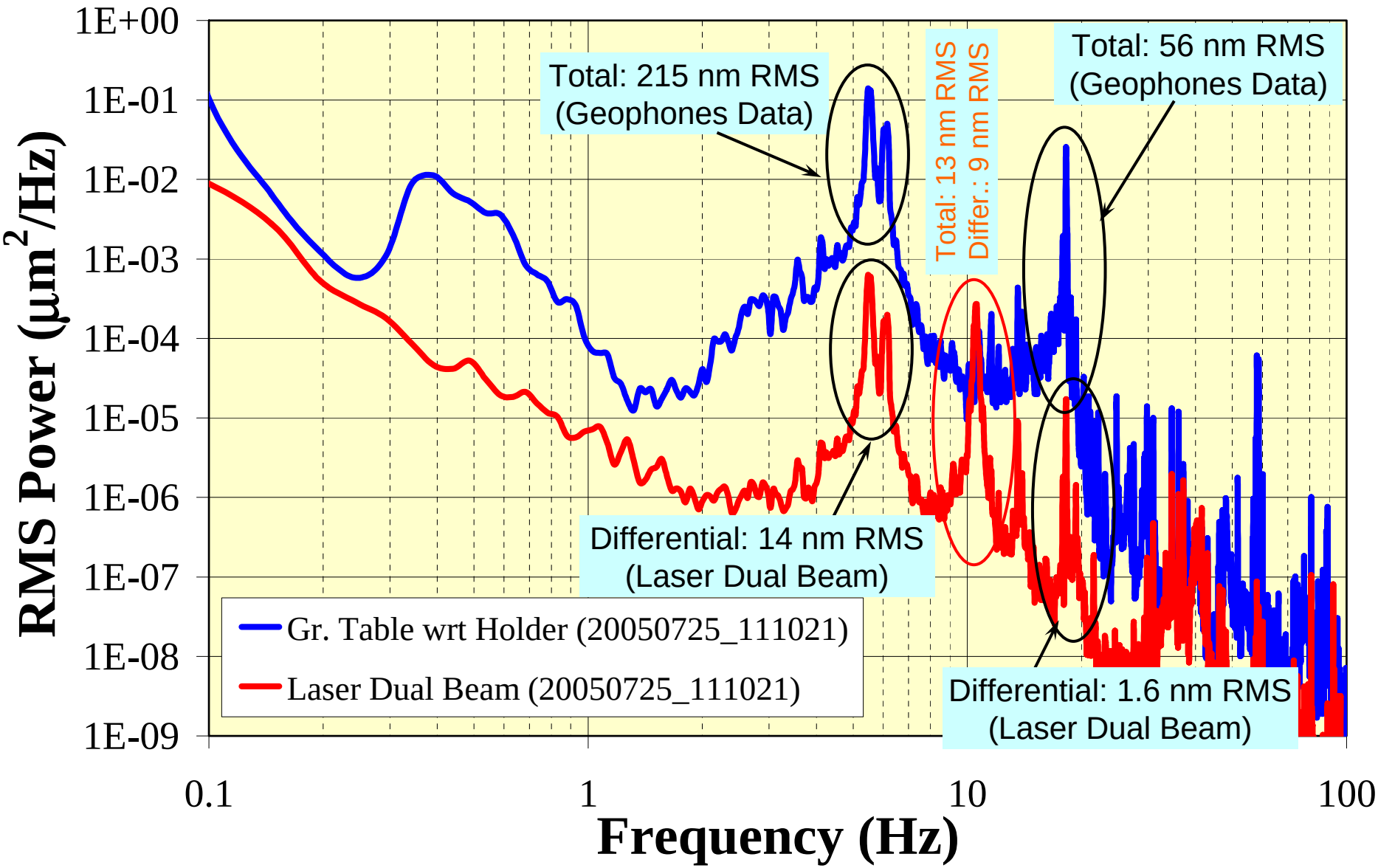
System Performance: Differential Mode

- Dual beam mode measures the differential motion between two points.
- If both the points are chosen to be on the side of the granite table, very near each other, then the true differential motion between the points can be assumed to be zero.
- The differential signal from the laser may be treated as an indication of system noise in this mode, except for any internal motion of the laser holders.
- Results show that the differential mode helps significantly in reducing the effects of common mode motion of the laser holder.

Performance Tests: Dual Beam Mode



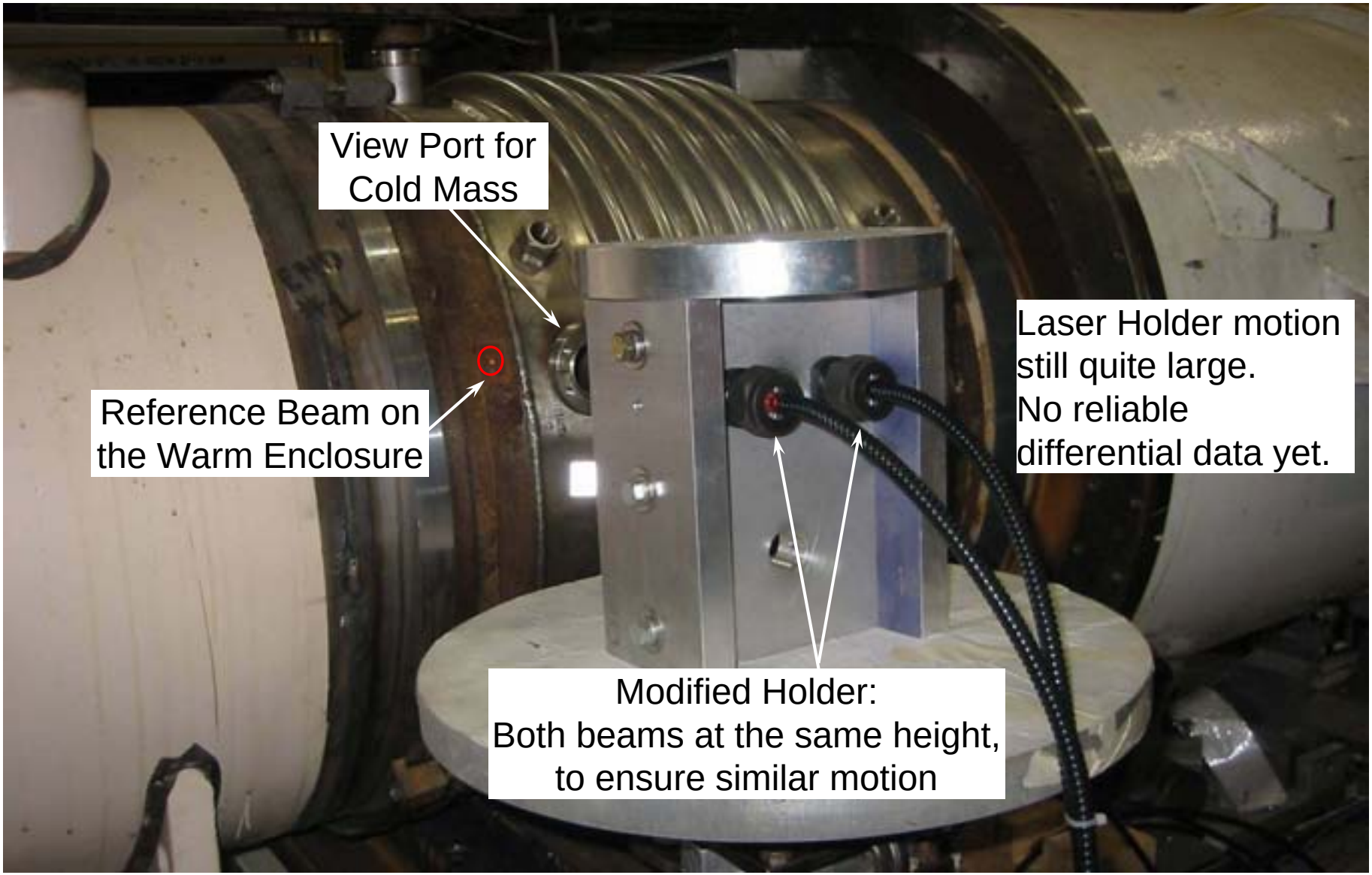
Differential Measurements with Dual Beams



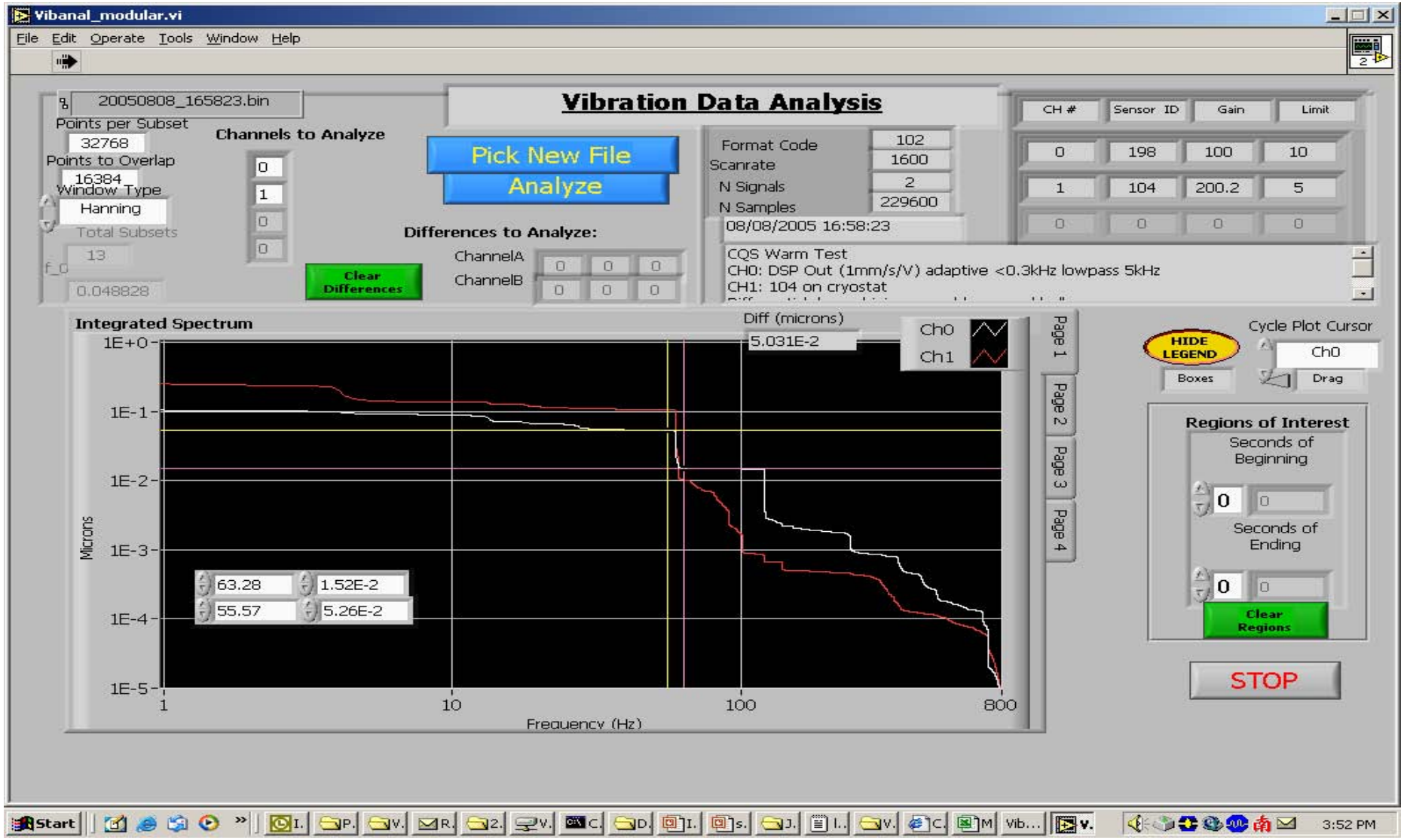
Summary of Laser Performance Tests

- Intrinsic noise, based on both beams terminated by mirrors, is below 1 nm/$\sqrt{\text{Hz}}$ above ~ 2 Hz.
- Single beam measurements pick up motion of both the object and the laser head.
- Single beam measurements are consistent with motion derived from geophone data.
- Dual Beam differential data are consistent with the intrinsic noise (<1 nm/$\sqrt{\text{Hz}}$ above ~ 2 Hz) when the absolute motion is also small.
- Absolute motion is largely suppressed (>10X) in the differential mode for most frequencies. An exception was 11 Hz peak, which was not significantly suppressed.
- Results look promising for the CQS test. However, still need to keep the absolute motion of laser heads small.

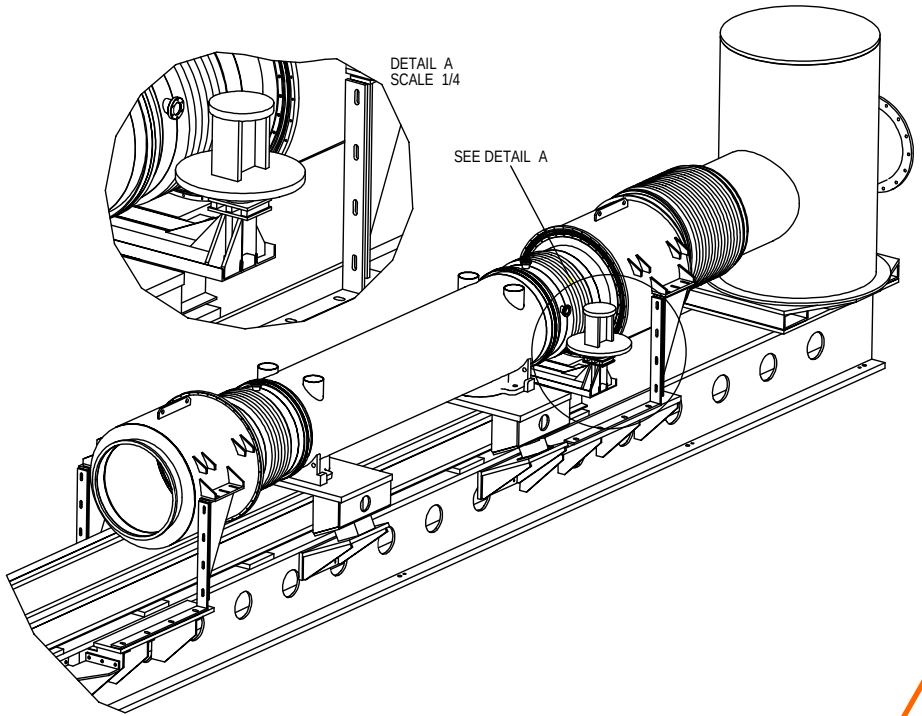
Laser Set up for Horizontal Measurements

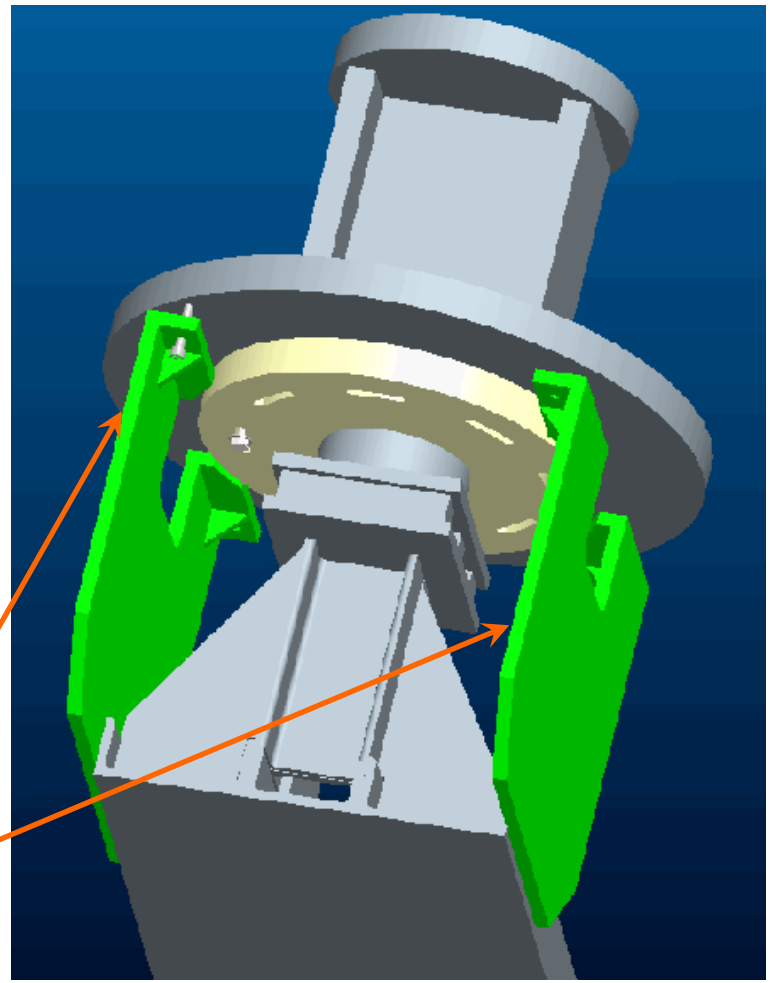


Differential Beam Horizontal Measurements



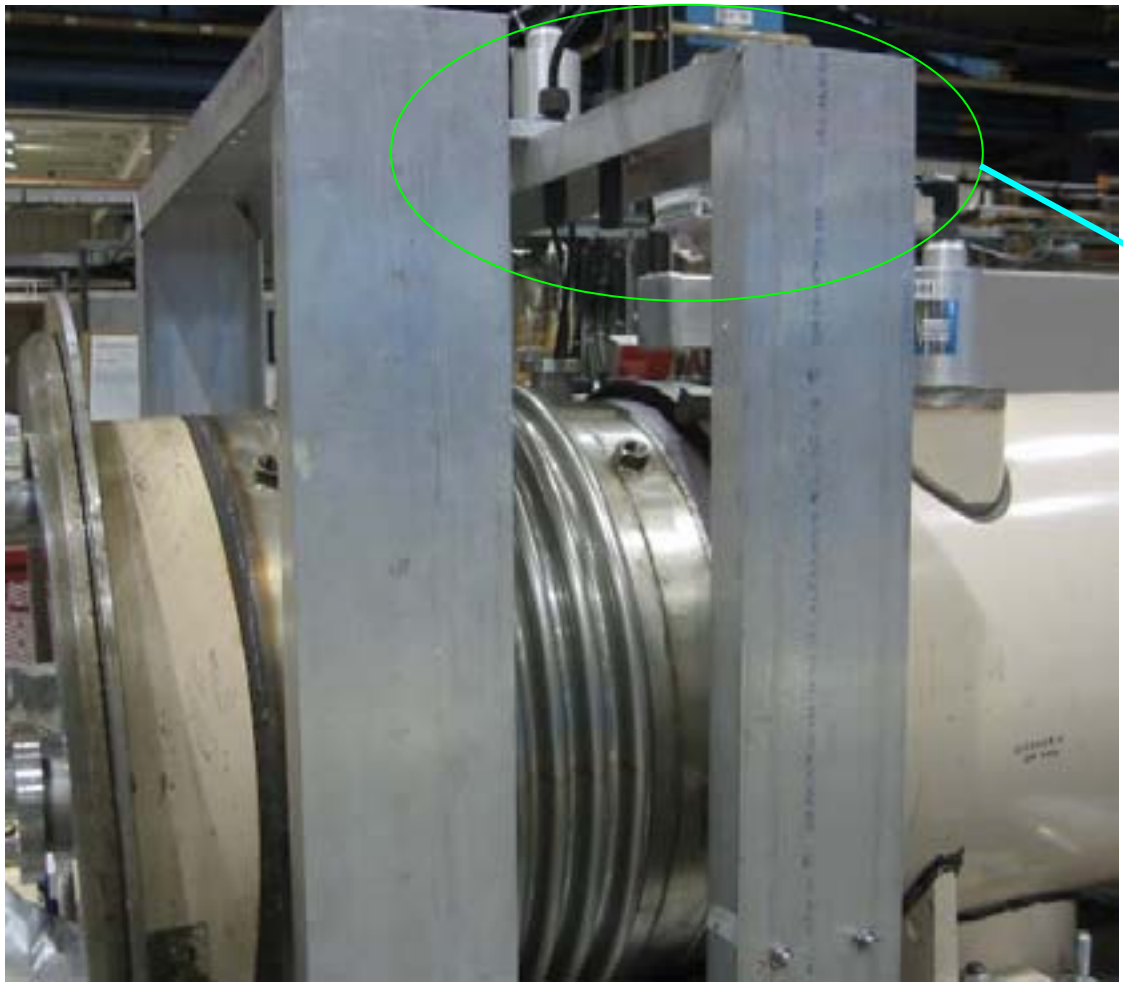
Modifications for the Horizontal Laser Holder

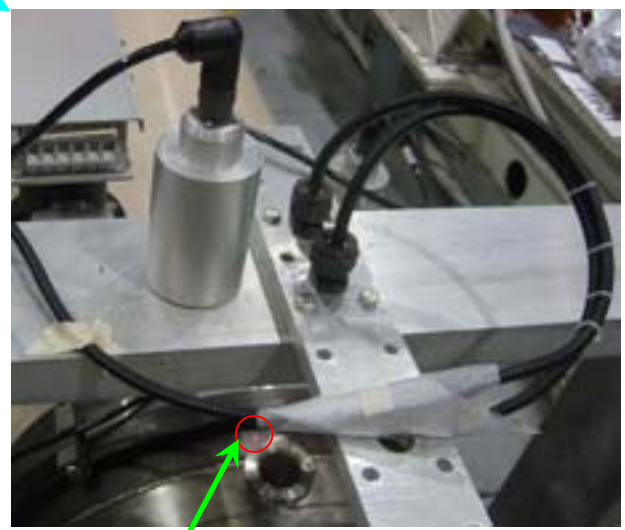




Two side supports to be added

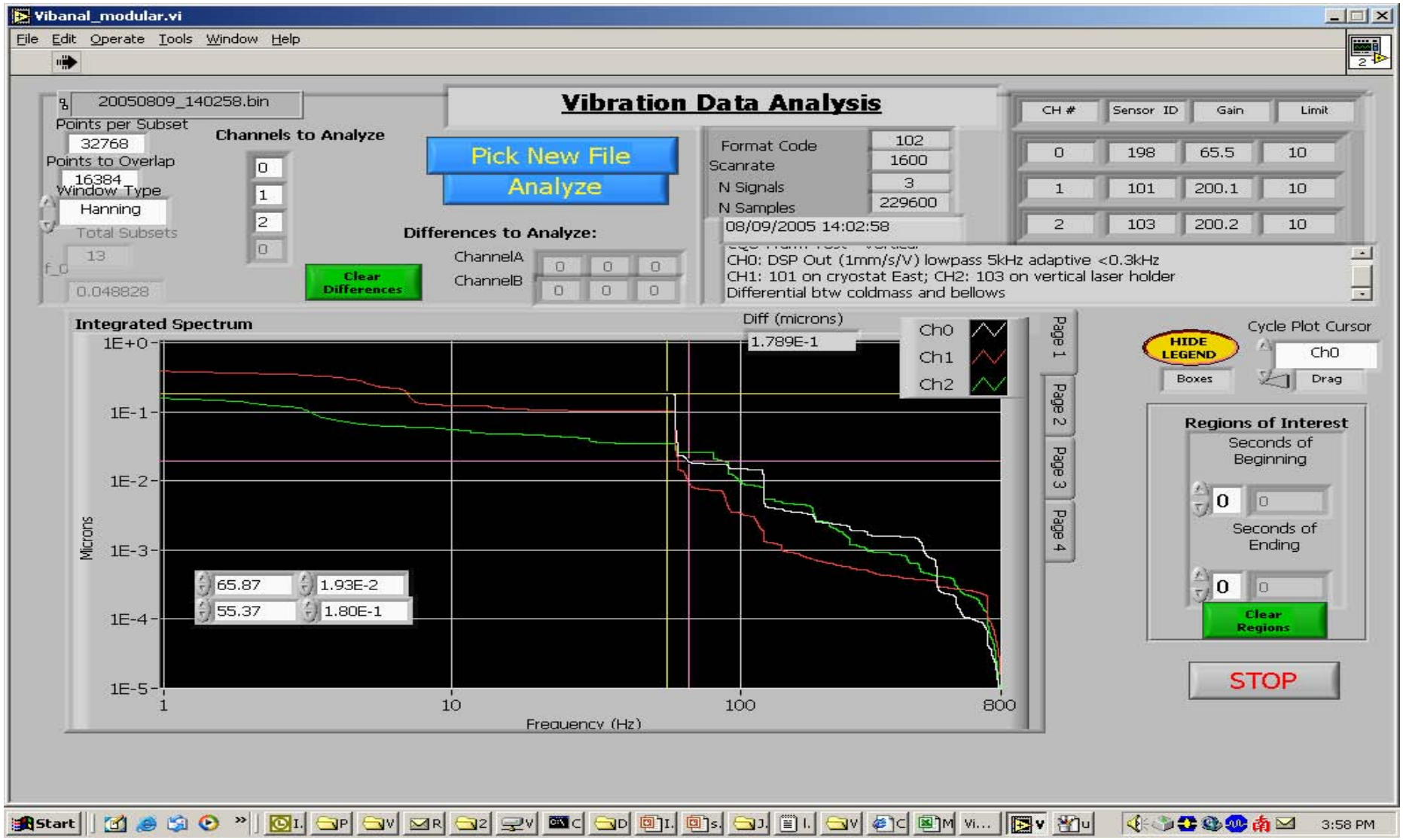
Laser Set up for Vertical Measurements



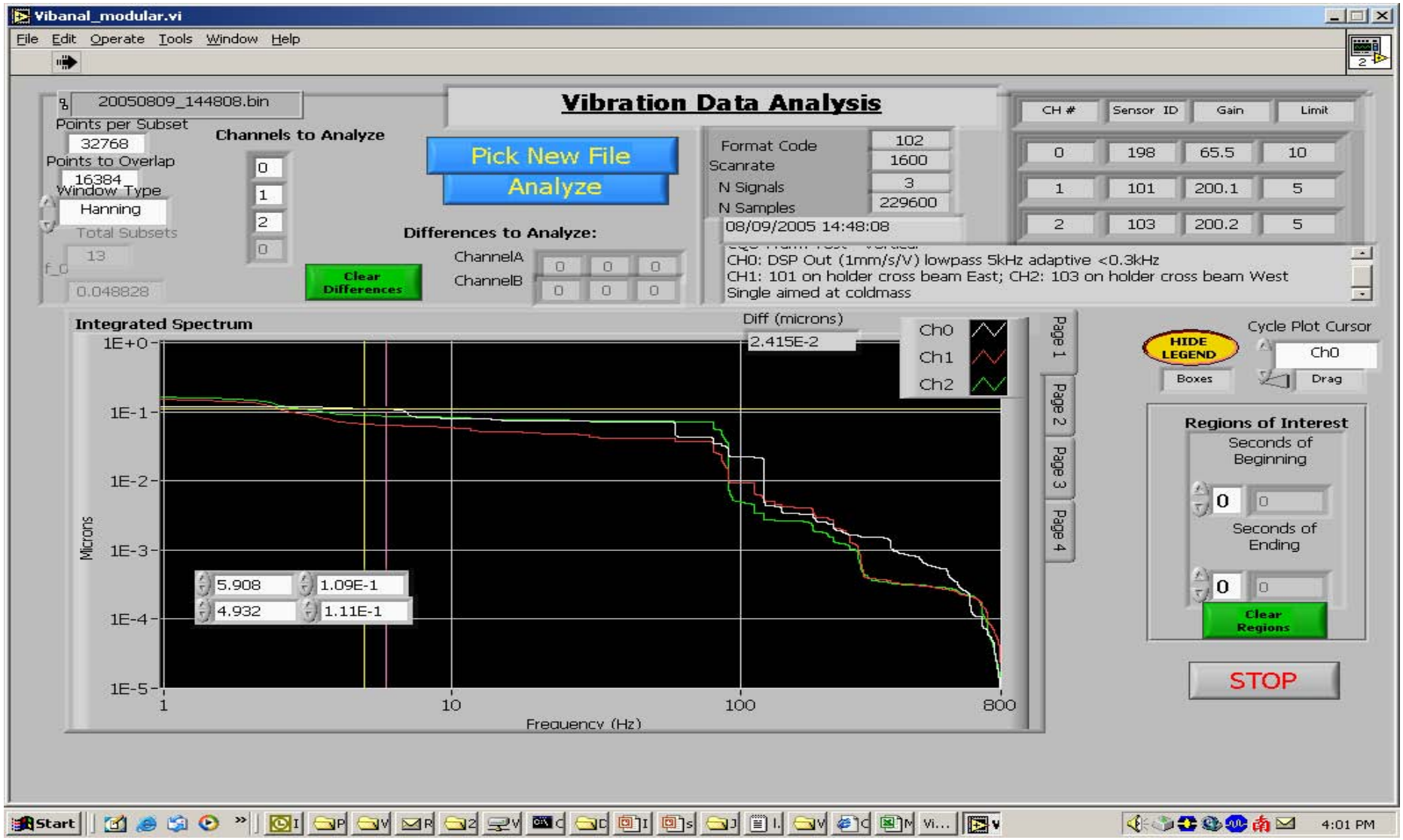


Reference Beam on
the Warm Enclosure

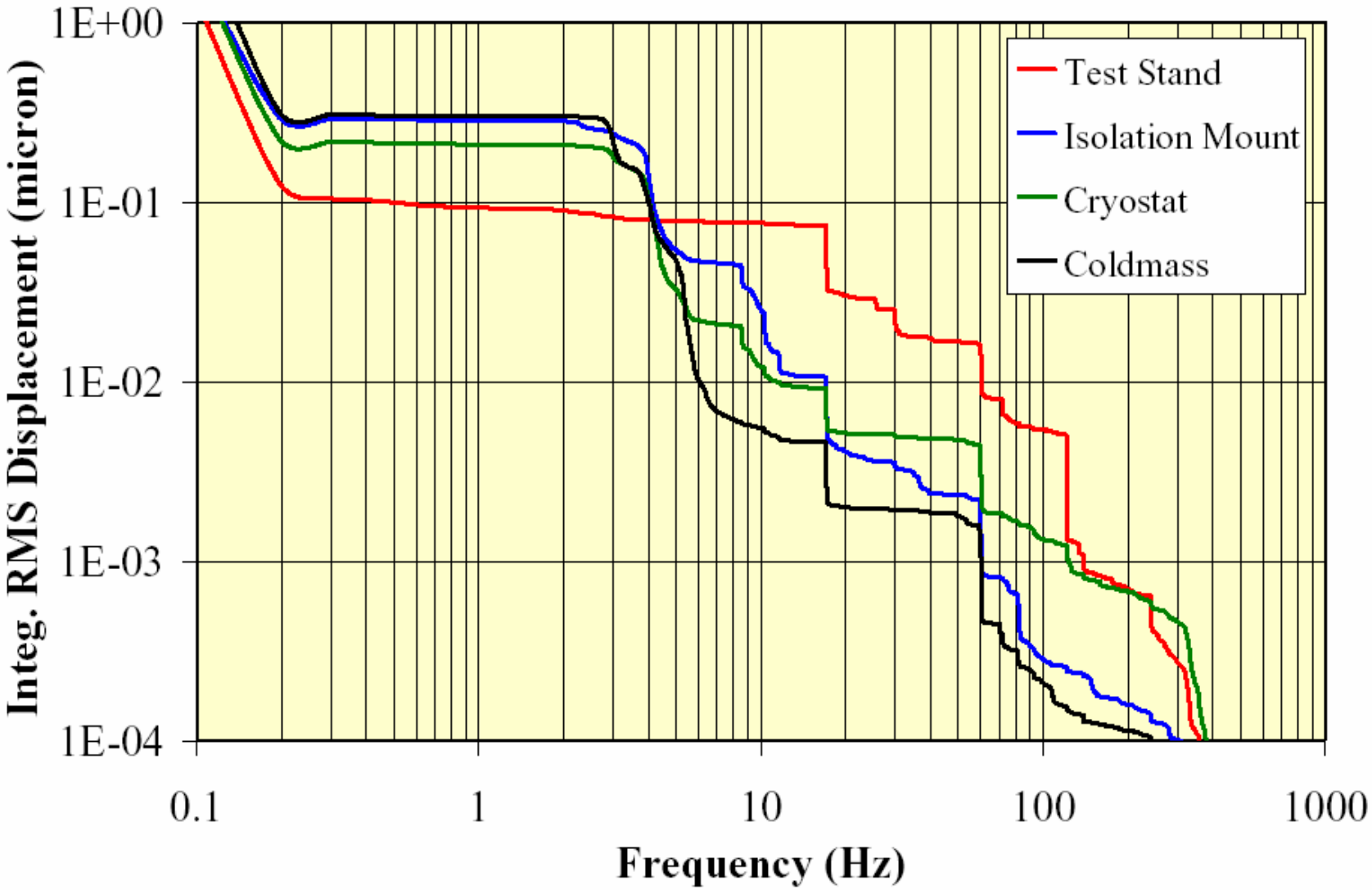
Differential Beam Vertical Measurements



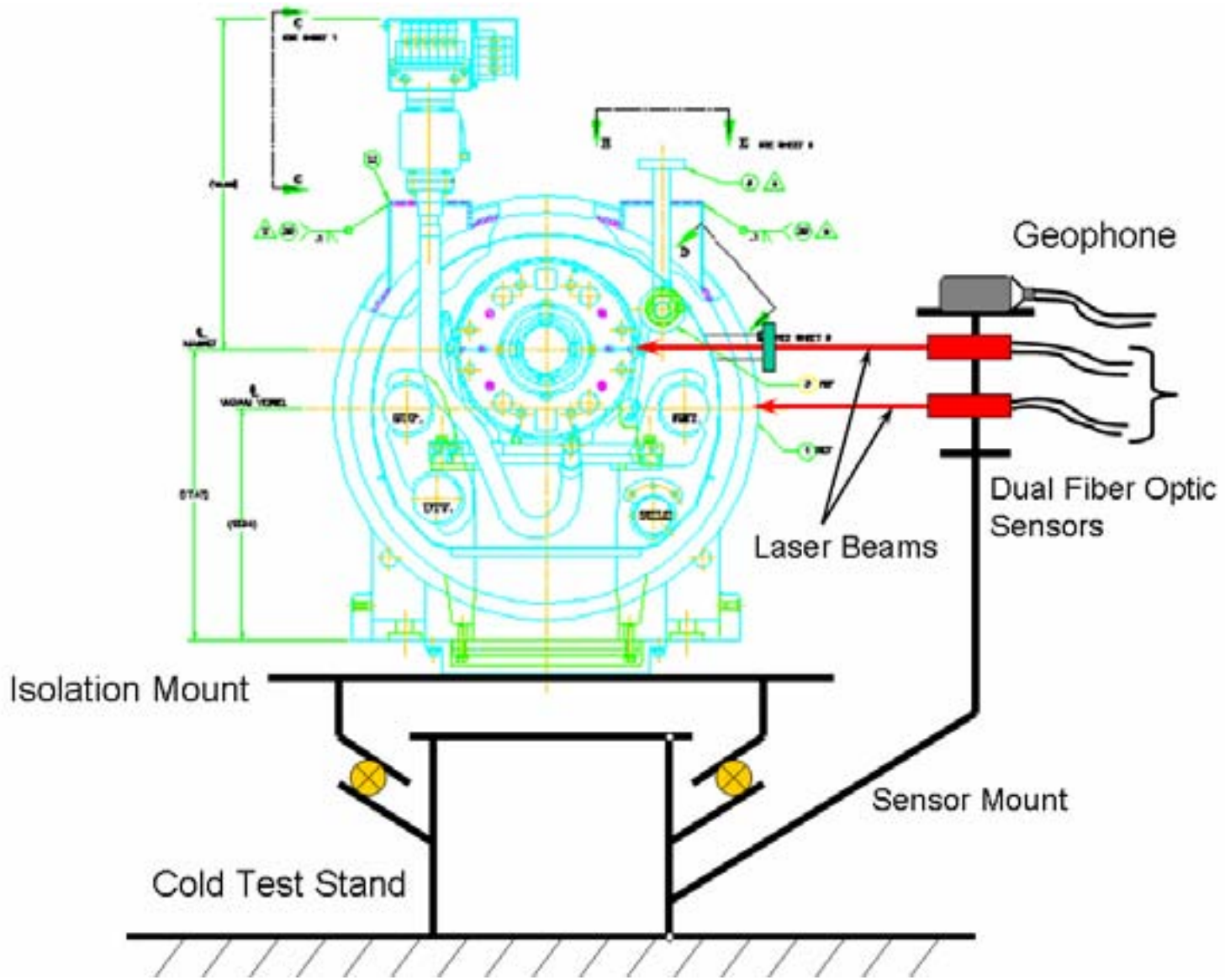
Single Beam Vertical Measurements



CQS Vibrations along Vertical Axis(Feb'04)



CQS Test Stand



Status of CQS Tests

- Work has started to install the CQS magnet, along with necessary fixtures, in the test bay.
- We continue to make modifications to the laser holder to minimize the absolute, as well as the relative motion of the two laser heads.
- Cryostat motion is much higher compare to coldmass now, after CQS hooked up to cryo-station, if this motion still same, maybe we need to find the new location which the reference beam shoot on.
- CQS scheduled for vibration tests around the beginning of September'05. *Possible presentation at Nanobeam 2005*?