Second RHIC CQS Cold Test Using Laser Vibrometer after Reducing the Laser Holder Motion

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Introduction

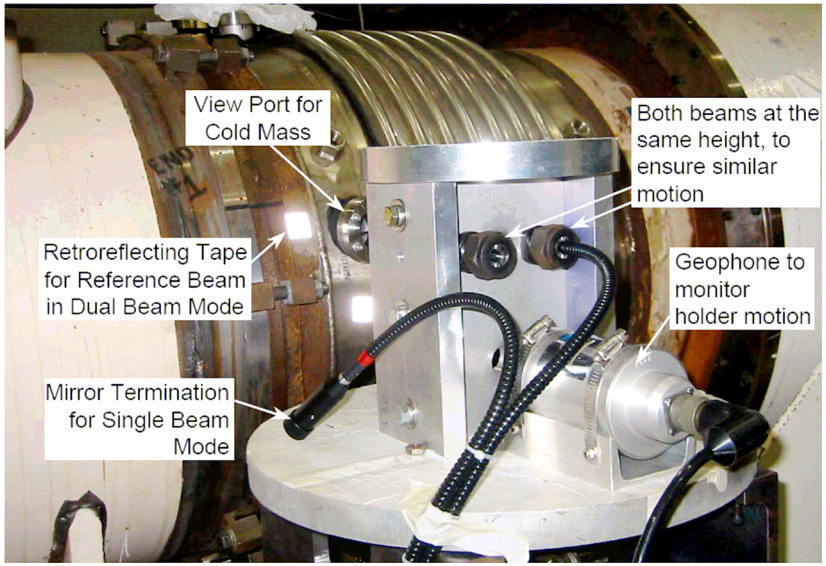
- PolyTec Laser Doppler Vibrometer system was used to measure the CQS coldmass vibrations under cryogenic conditions. The results were presented at the TeleConference on Oct.11, 2005, and at Nanobeam2005.
- In the horizontal measurements, the laser holder motion was about 300 nm RMS integrated above 1 Hz. This motion limits the sensitivity and accuracy of these measurements.
- The motion of the magnet itself was also large, but is relatively difficult to control in the present set up.
- It is desirable to reduce the motion of the laser holder as a first step towards improving the measurement quality.

Reducing the Motion of the Laser Holder

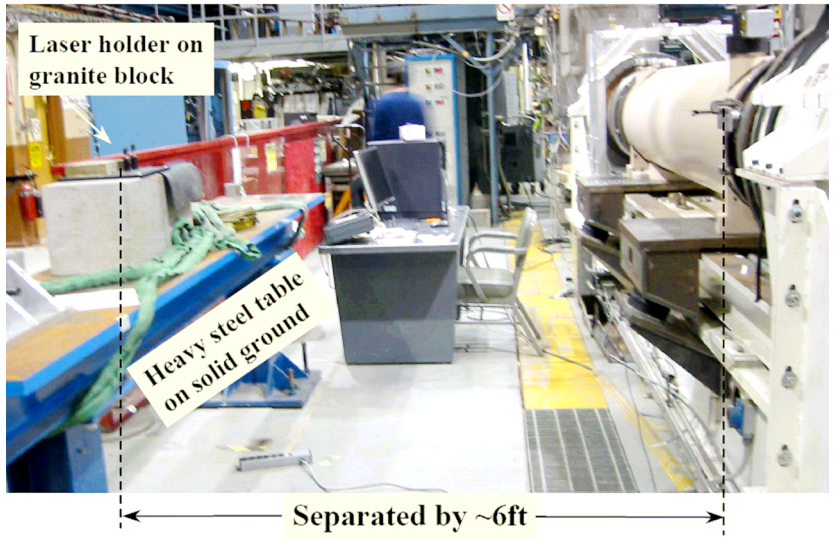
- Preliminary work was presented in the phone meeting on Jan. 9, 2006.
- Main features:
  - Detach laser holder from the test stand
  - Use some form of isolation/stabilization for the laser holder to bring its motion to negligible levels, at least for frequencies above a few Hz.
  - Ideally, with the laser holder motion under control, the single beam mode should provide good **absolute** measurement (like a geophone!)

Recap: Detaching Laser Holder Helps

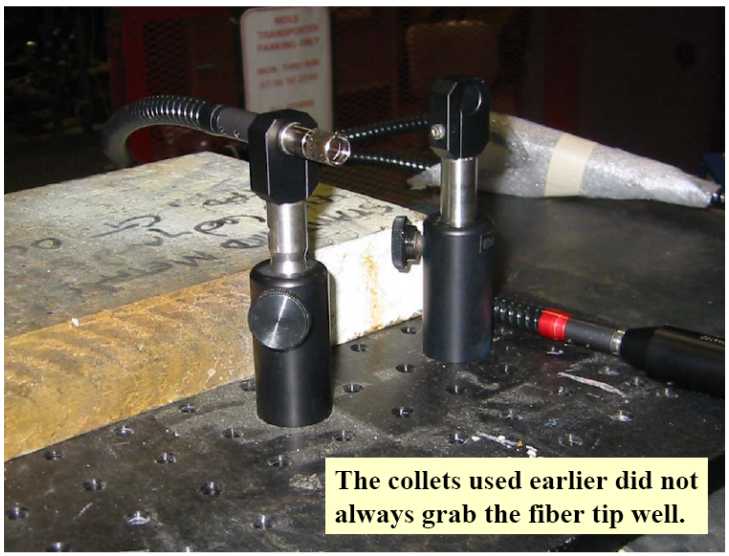
Laser Holder attached to the Yellow Stand



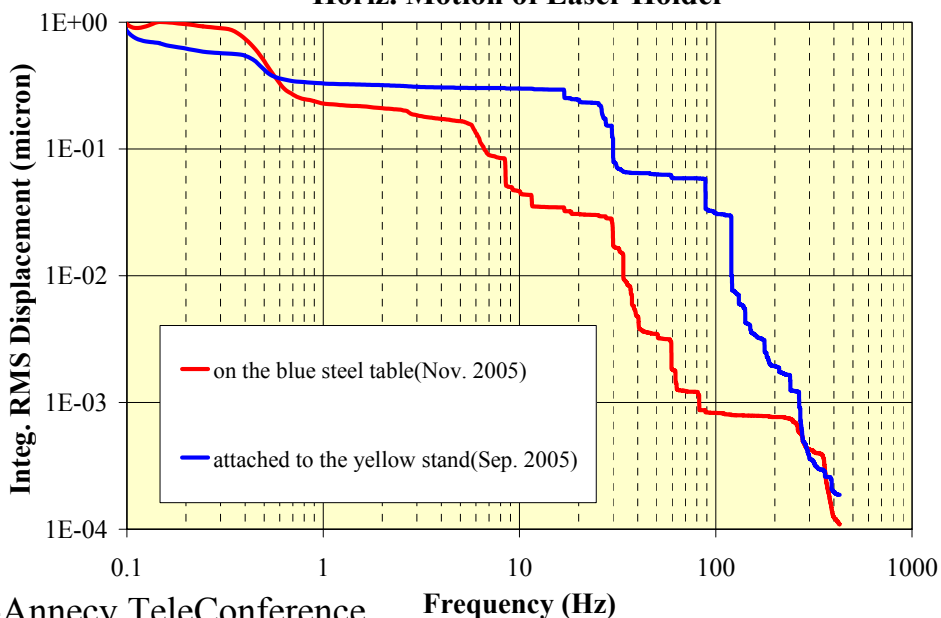
Step 1: Detach Holder from Test Stand



New Clamps for the Laser Fiber Heads



Horiz. Motion of Laser Holder



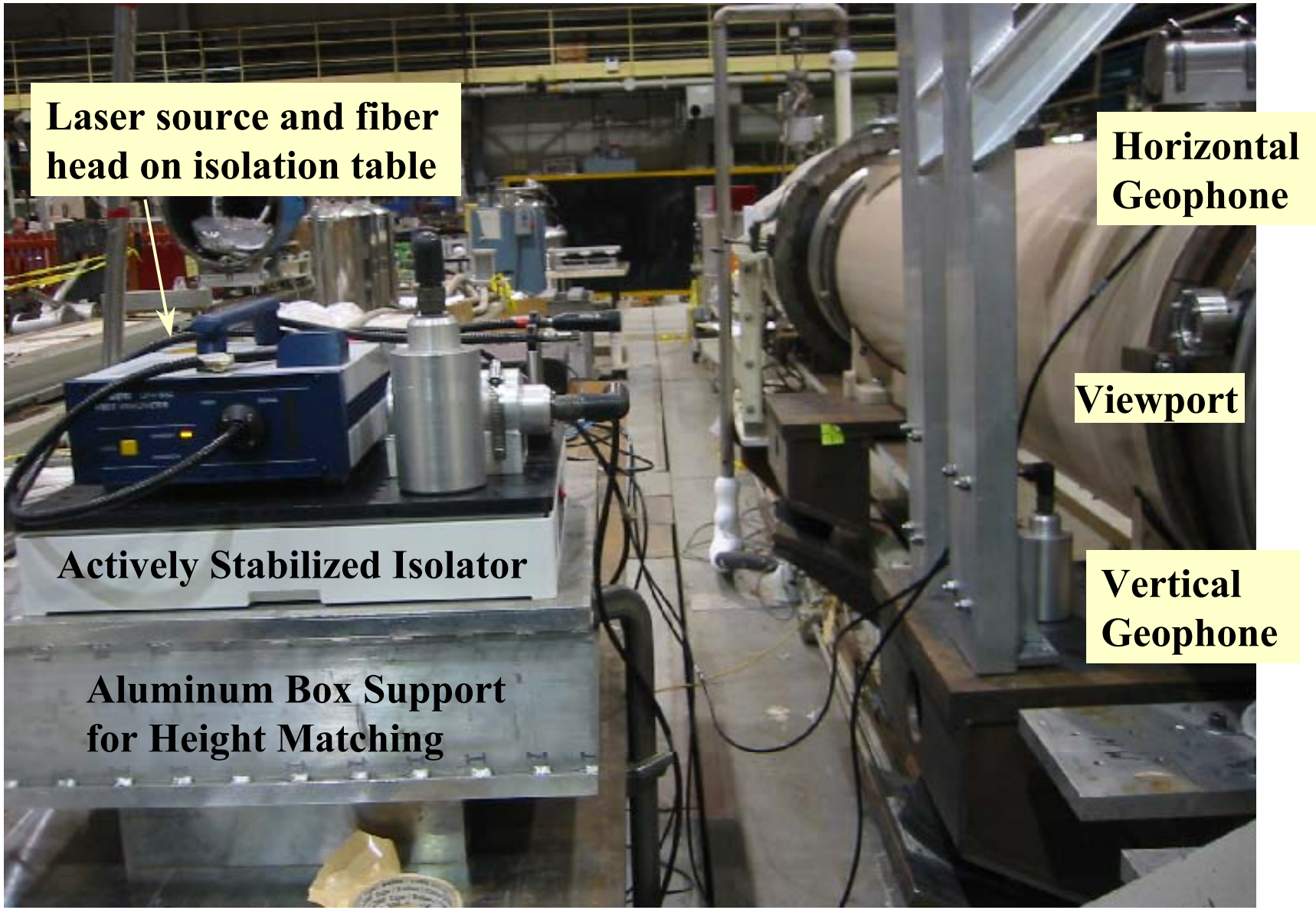
Further Reduction of the Laser Head Motion

- The laser head motion is below ~10 nm only above ~35 Hz, and below ~1 nm only above ~100 Hz.
- For "absolute" measurements, it is necessary to significantly reduce this motion.
- An actively stabilized isolation table was studied at the BNL light source, and results looked promising (reported at the January 9, 2006 meeting).
- A similar table was ordered (~$8K), and was received in mid-Feb. This turned out to be defective!
- A replacement table was finally received in early March, which worked well.

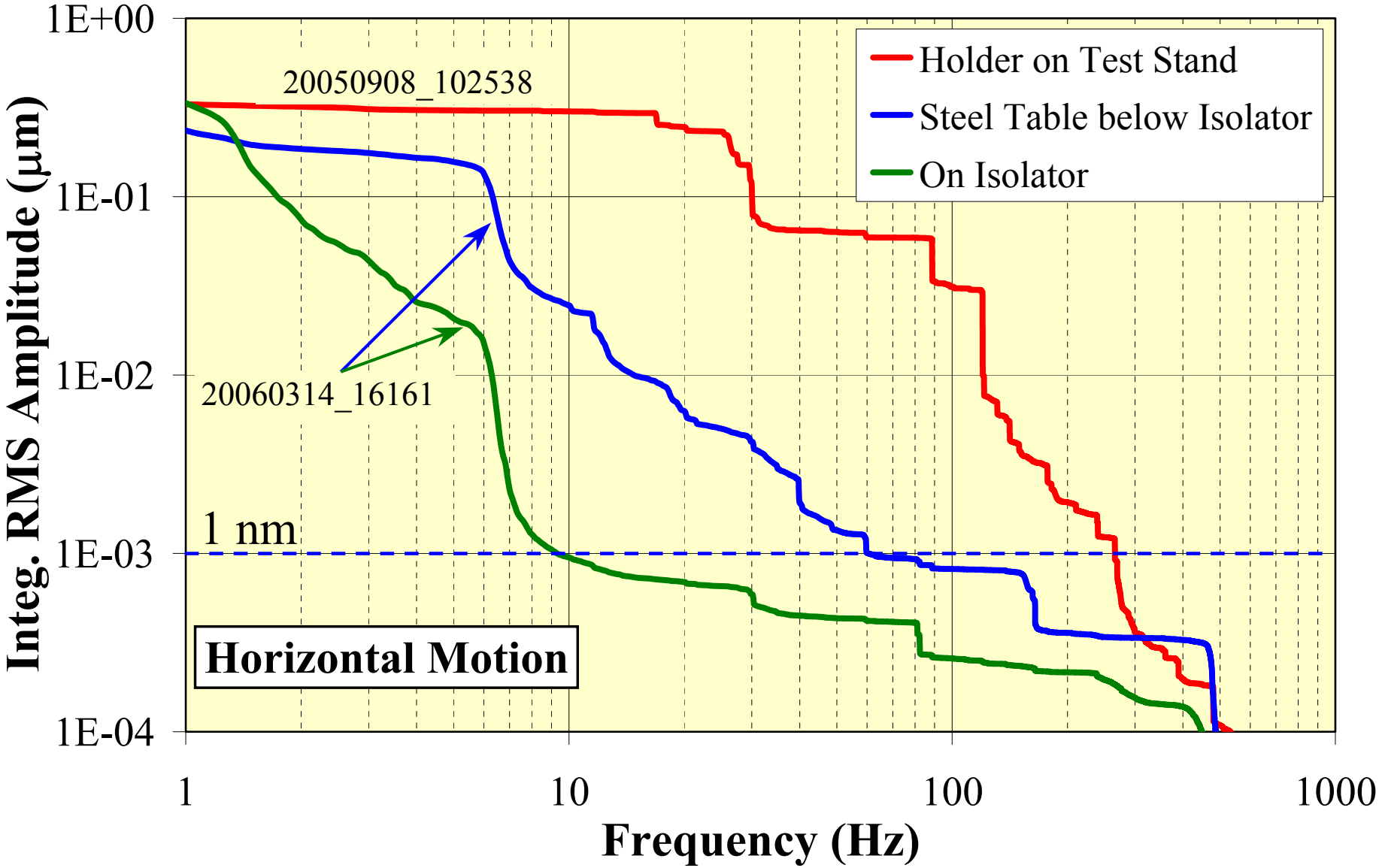
New CQS Cold Test Set Up

- Aluminum box supported on 3 rails, mounted on the blue table. (Used for matching height.)
- Clamped aluminum box to the steel table with large C-clamps.
- Isolation table placed on the aluminum box.
- New clamps to hold the fiber heads.
- Laser source/interferometer also placed on the isolation table $\Rightarrow$ **found to be very effective!**
- Geophones on the isolation table, on the cryostat (horizontal) and on the isolation mount on the CQS test stand (Vertical).

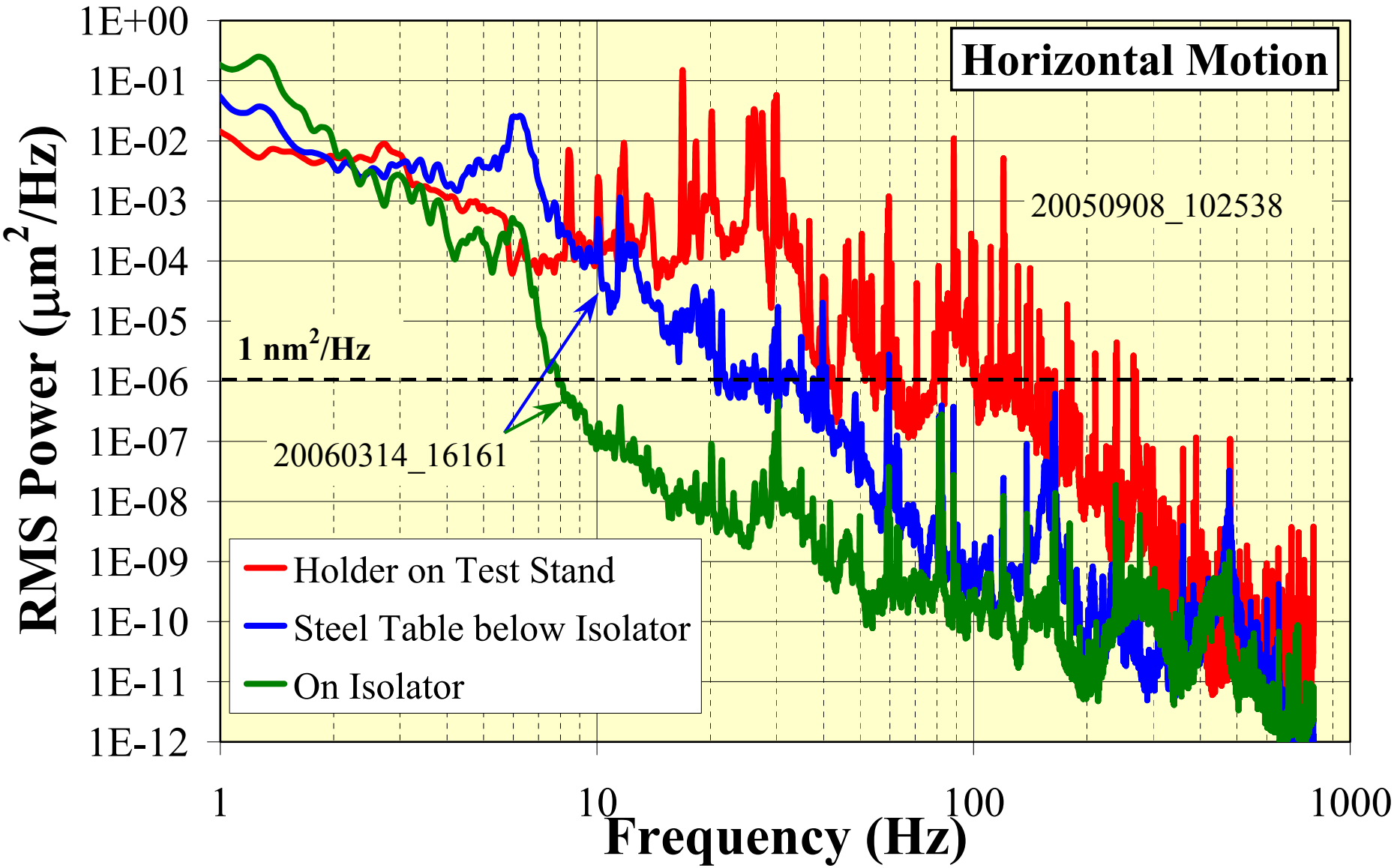
New CQS Cold Test Set Up



Holder Motion: With & Without Stabilization



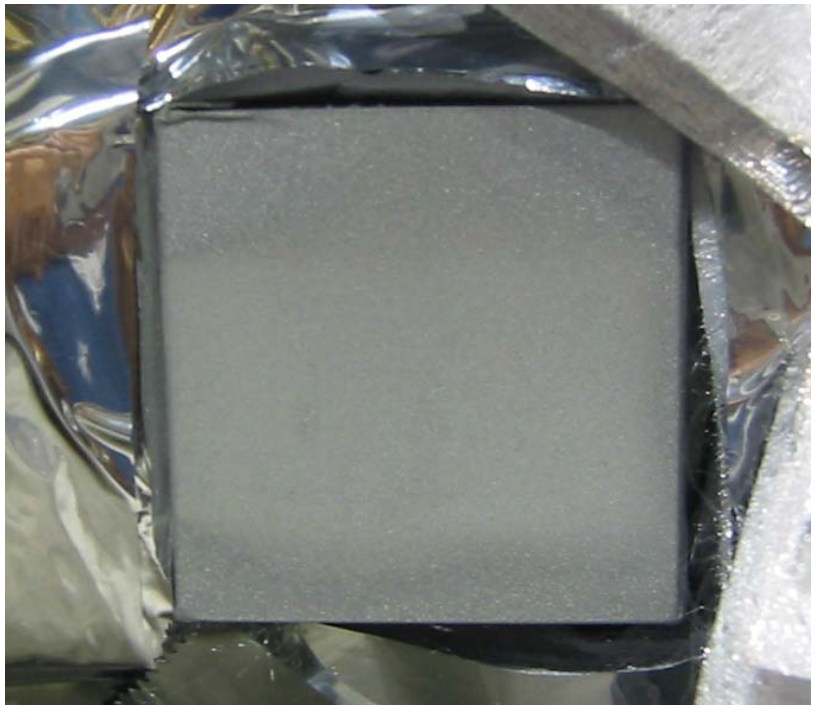
Holder Motion: With & Without Stabilization



Difficulties During this Cold Test

- We were unable to obtain ***any*** laser signal back from the target on the cold mass after the magnet was cooled down. This nearly killed the experiment.
- We had set up to measure at an end of the magnet different from the previous cold test in September'05.
- A visual comparison with the retro-reflecting target on the end used previously showed a difference in the color of the reflective tape. A quick check showed that the other target was still working.
- The entire set up had to be moved to the other side of the magnet, and the measurements were continued.
- The laser output kept fluctuating, making it difficult to do the measurements continuously.

Laser Reflector Inspection After Cold Test

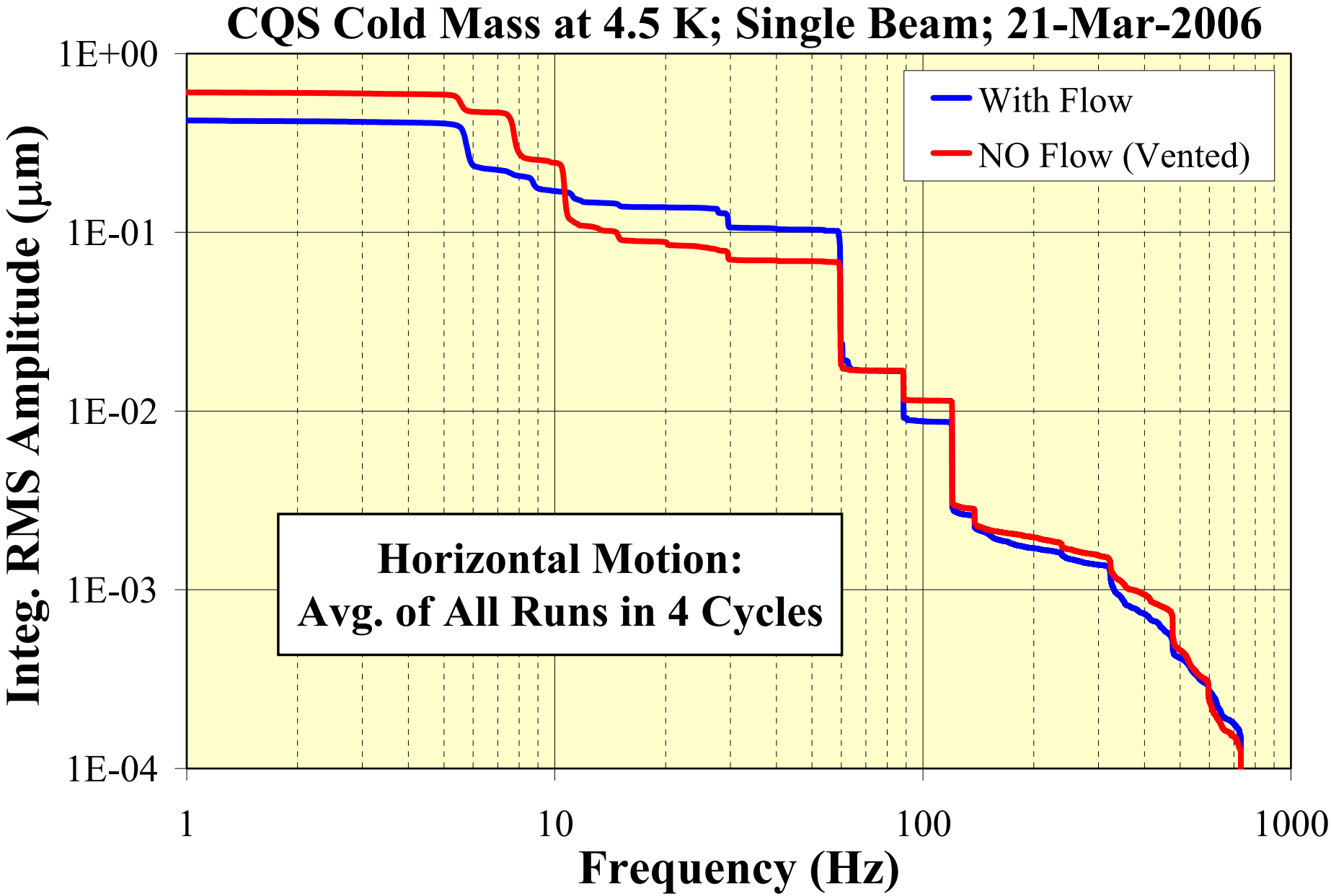


Central, exposed region does not reflect. The edges, which were covered by super-insulation, are still reflecting.

Picture taken with a flash, clearly showing the difference in reflectivity.

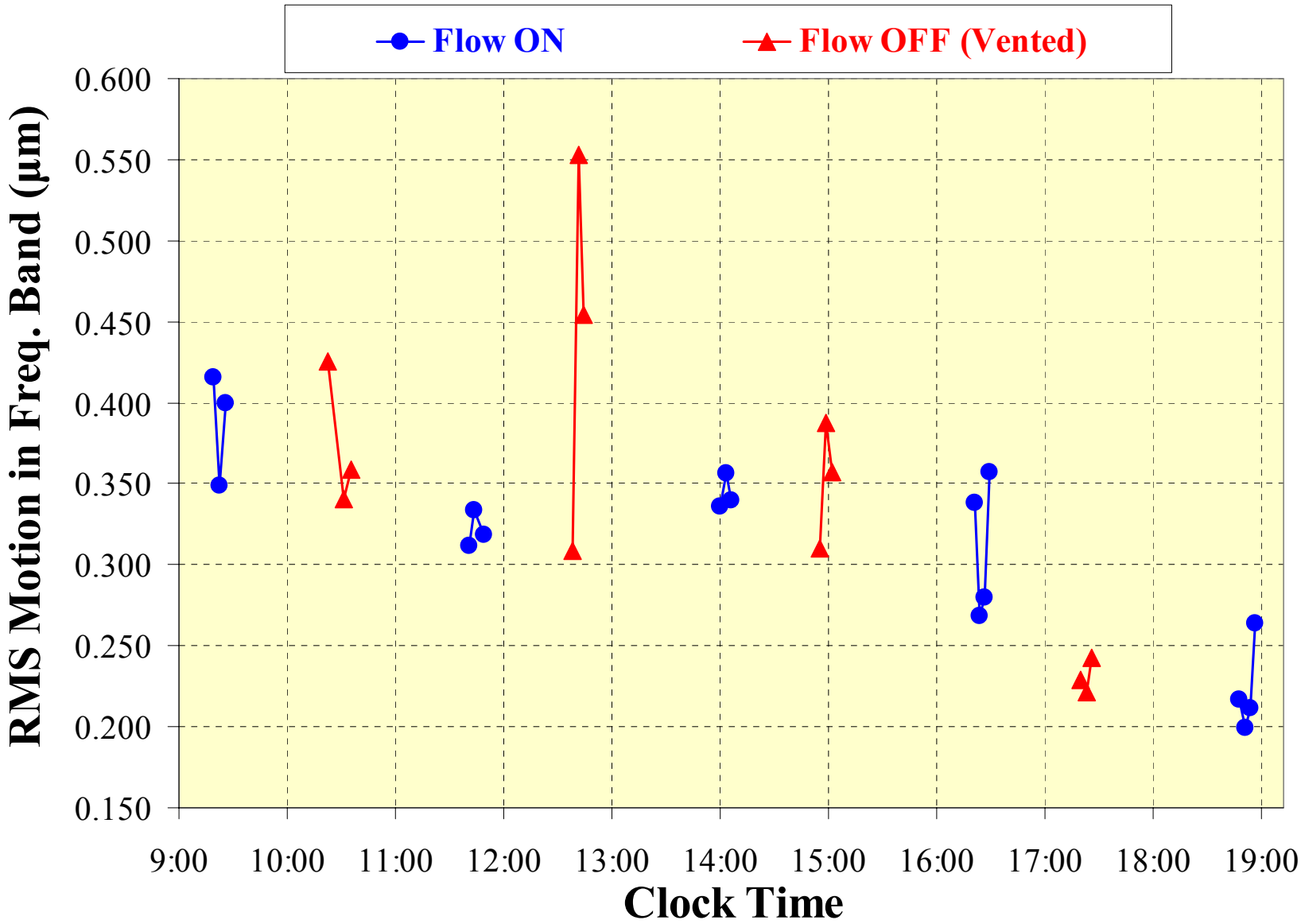
1st Set of Measurements: 21-Mar-2006

- Measurements were first made with the magnet at 4.5K, and with Helium flowing normally (typically 3 runs).
- The flow was then stopped from entering the magnet. The magnet was also vented to the Helium return line in order to avoid any pressure build up in the magnet.
- Measurements were made about 30 min. after the flow was stopped (typically 3 runs). The magnet temperature reached typically ~20 K.
- The flow was then resumed, and measurements with flow were repeated after ~1 hour wait.
- The entire sequence of Flow/No Flow measurements was repeated four times on the same day.
- All measurements were in the single beam mode.


CQS Cold Mass at 4.5 K; Single Beam; 21-Mar-2006
Integ. RMS Amplitude (μm)
1E+00
1E-01
1E-02
1E-03
1E-04
1
10
100
1000
Frequency (Hz)
With Flow
NO Flow (Vented)
Horizontal Motion:
Avg. of All Runs in 4 Cycles

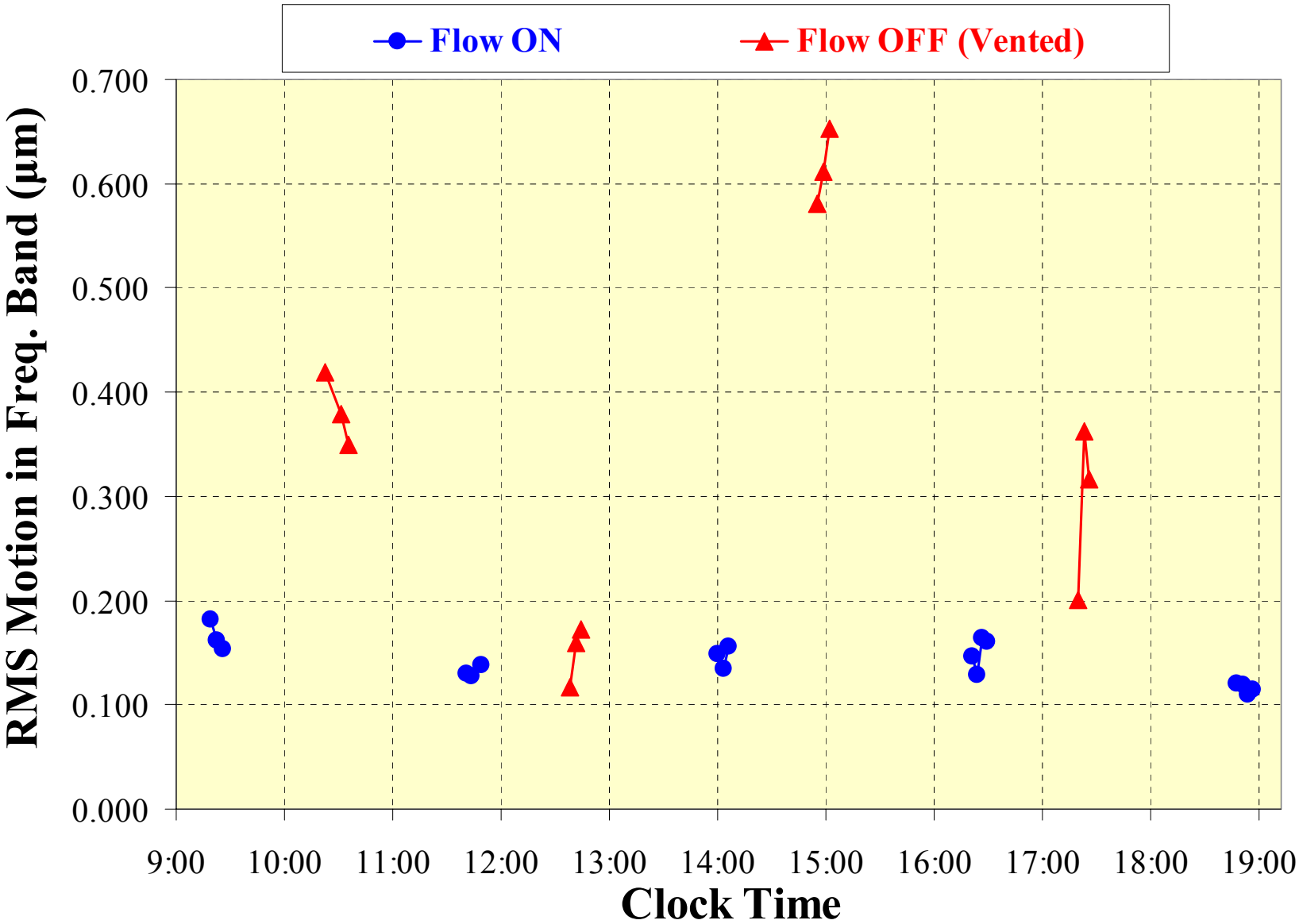
Laser Single Beam (Stabilized) on Cold Mass: 21 Mar'06

RMS Motion: 4.5 Hz to 6.5 Hz

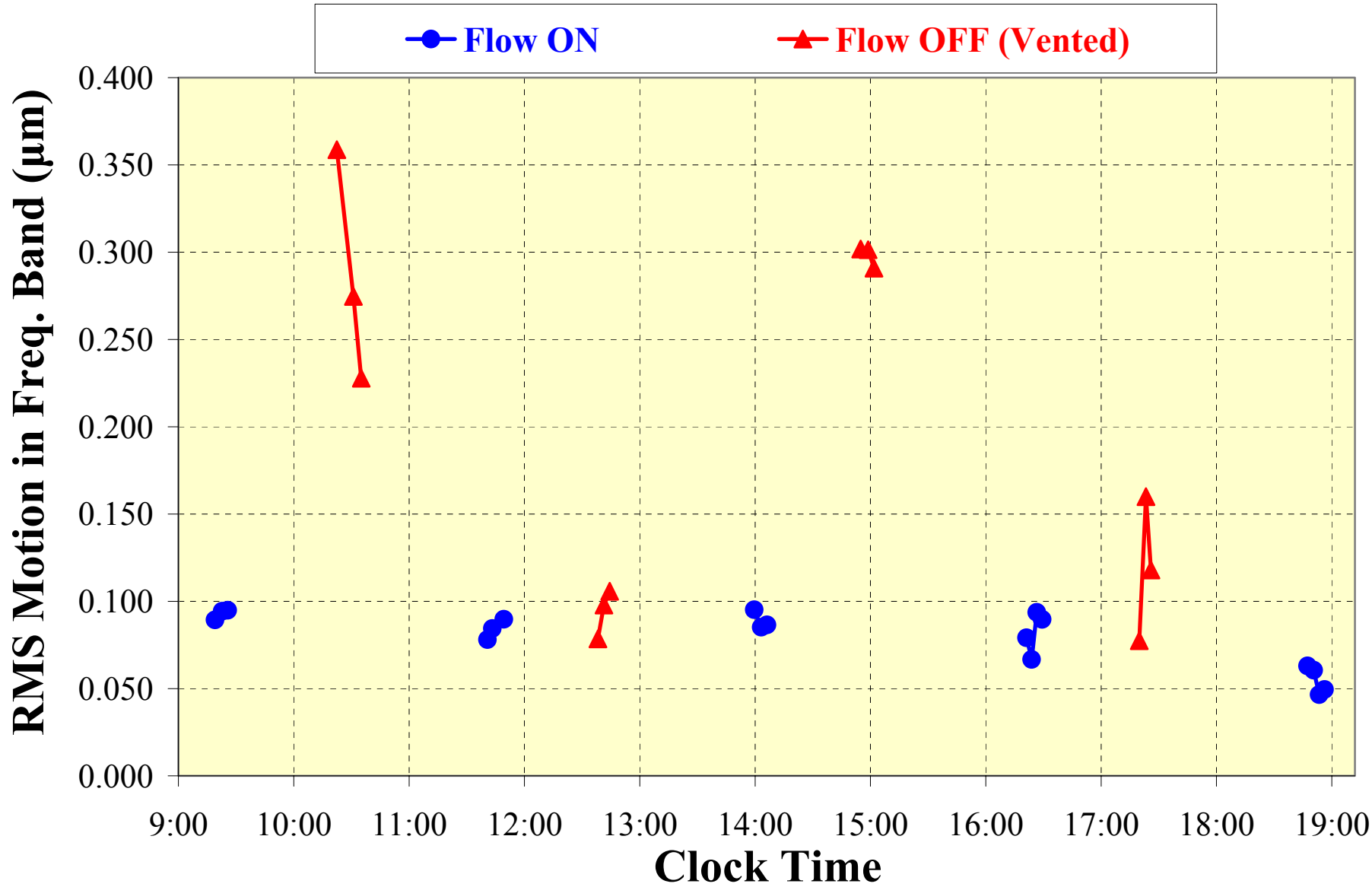


Laser Single Beam (Stabilized) on Cold Mass: 21 Mar'06

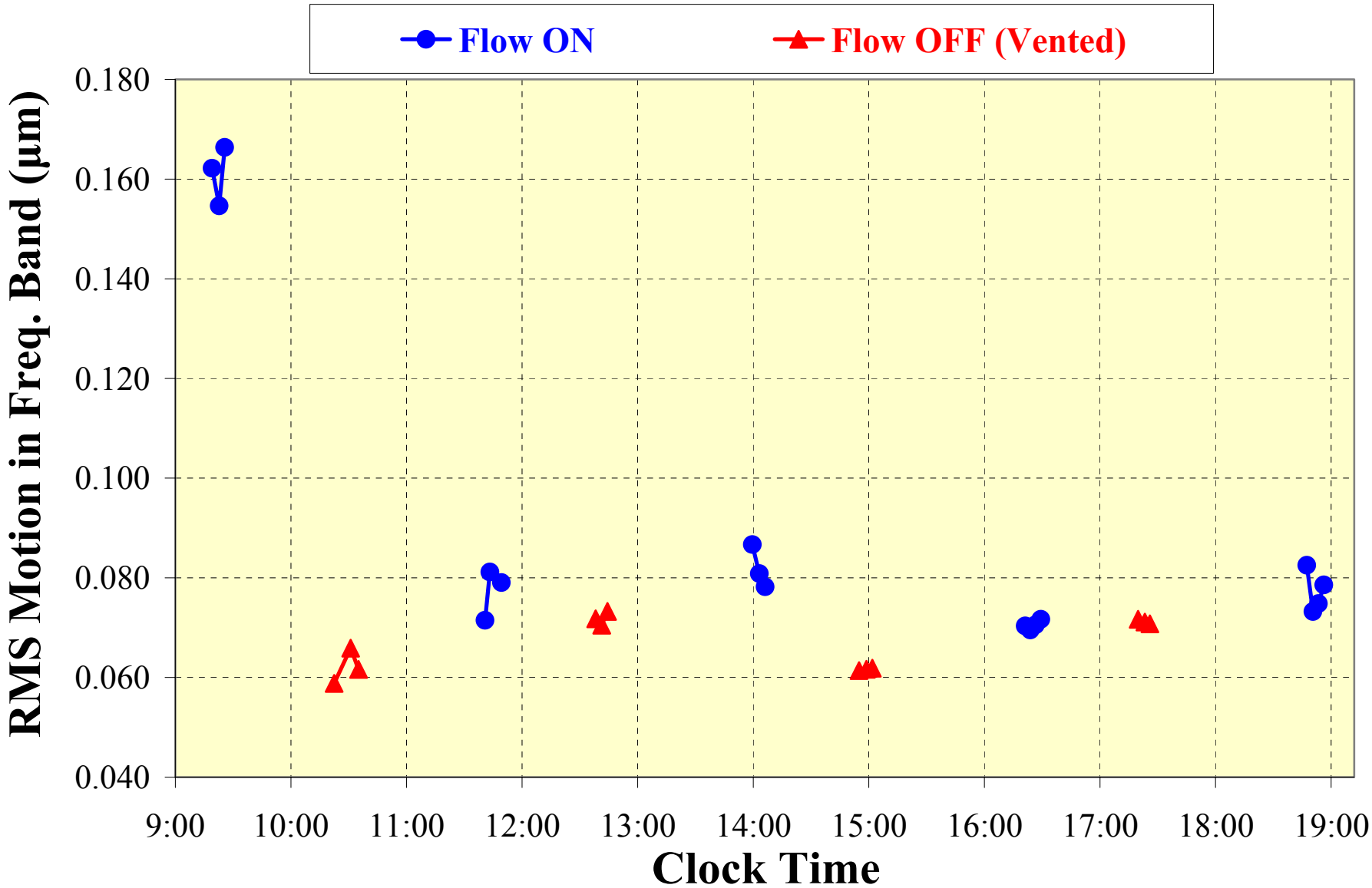
RMS Motion: 6.5 Hz to 10.0 Hz



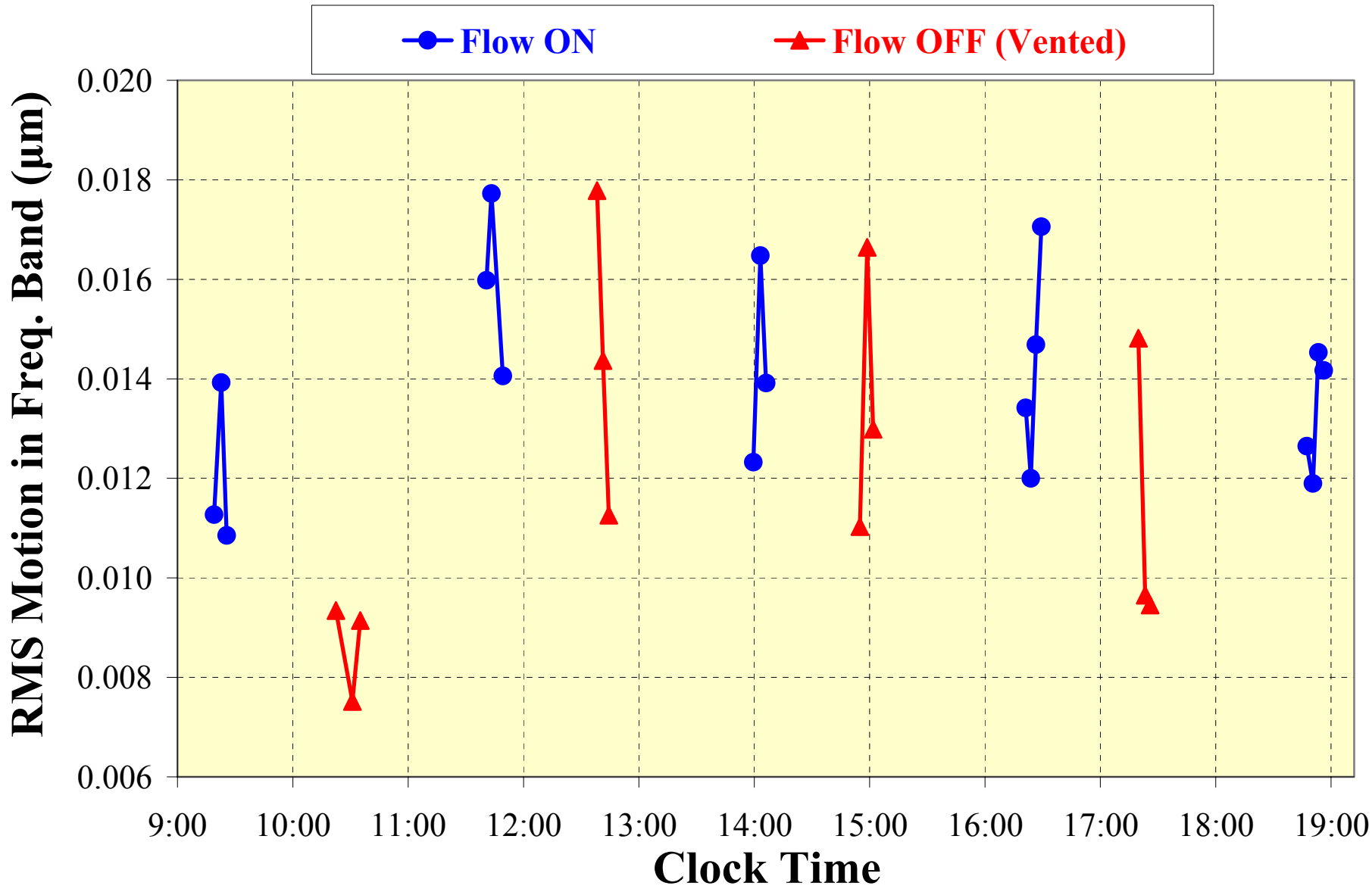
Laser Single Beam (Stabilized) on Cold Mass: 21 Mar'06
RMS Motion: 10.0 Hz to 13.5 Hz



Laser Single Beam (Stabilized) on Cold Mass: 21 Mar'06
RMS Motion: 45.0 Hz to 70.0 Hz

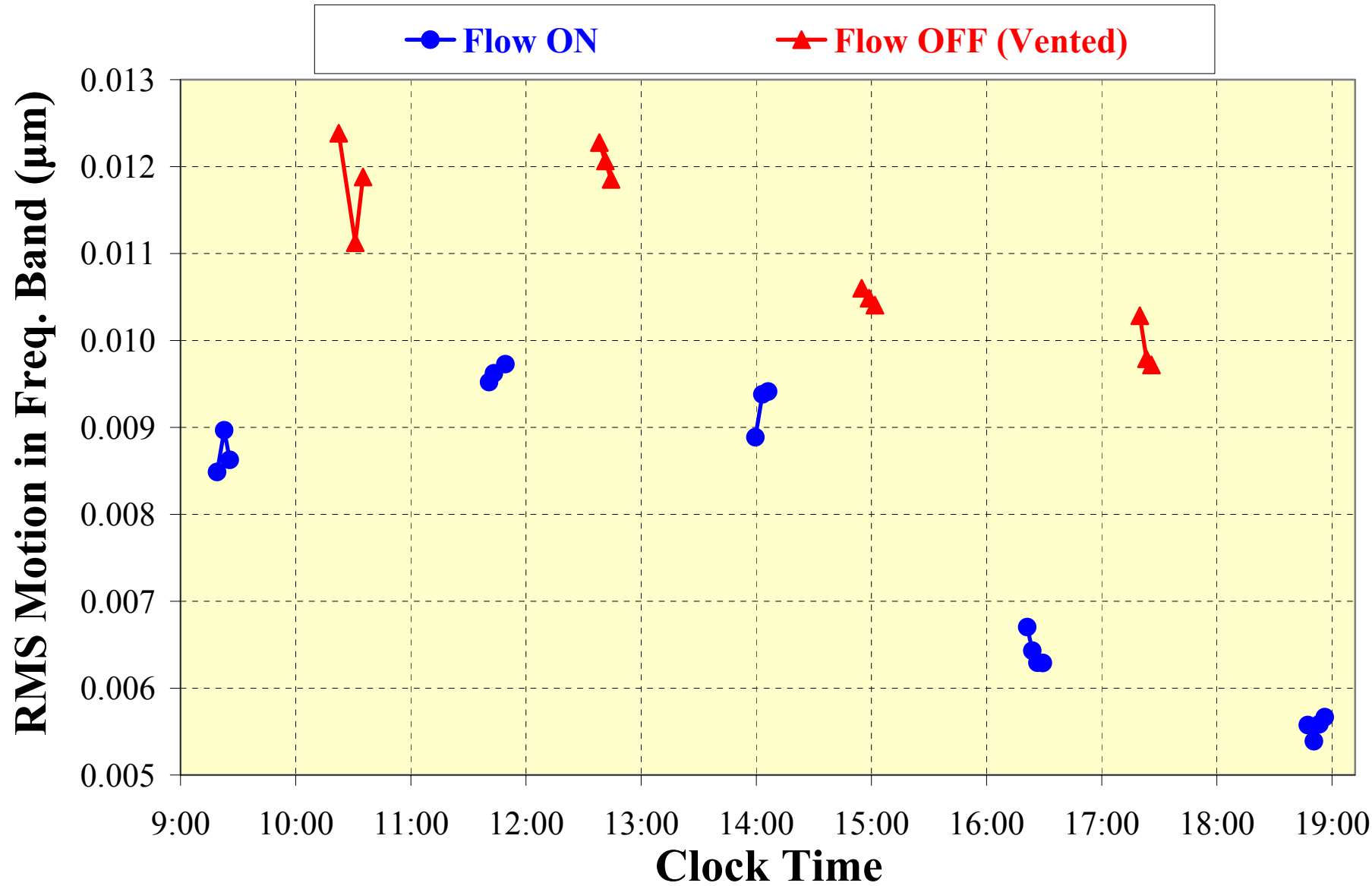


Laser Single Beam (Stabilized) on Cold Mass: 21 Mar'06
RMS Motion: 70.0 Hz to 95.0 Hz



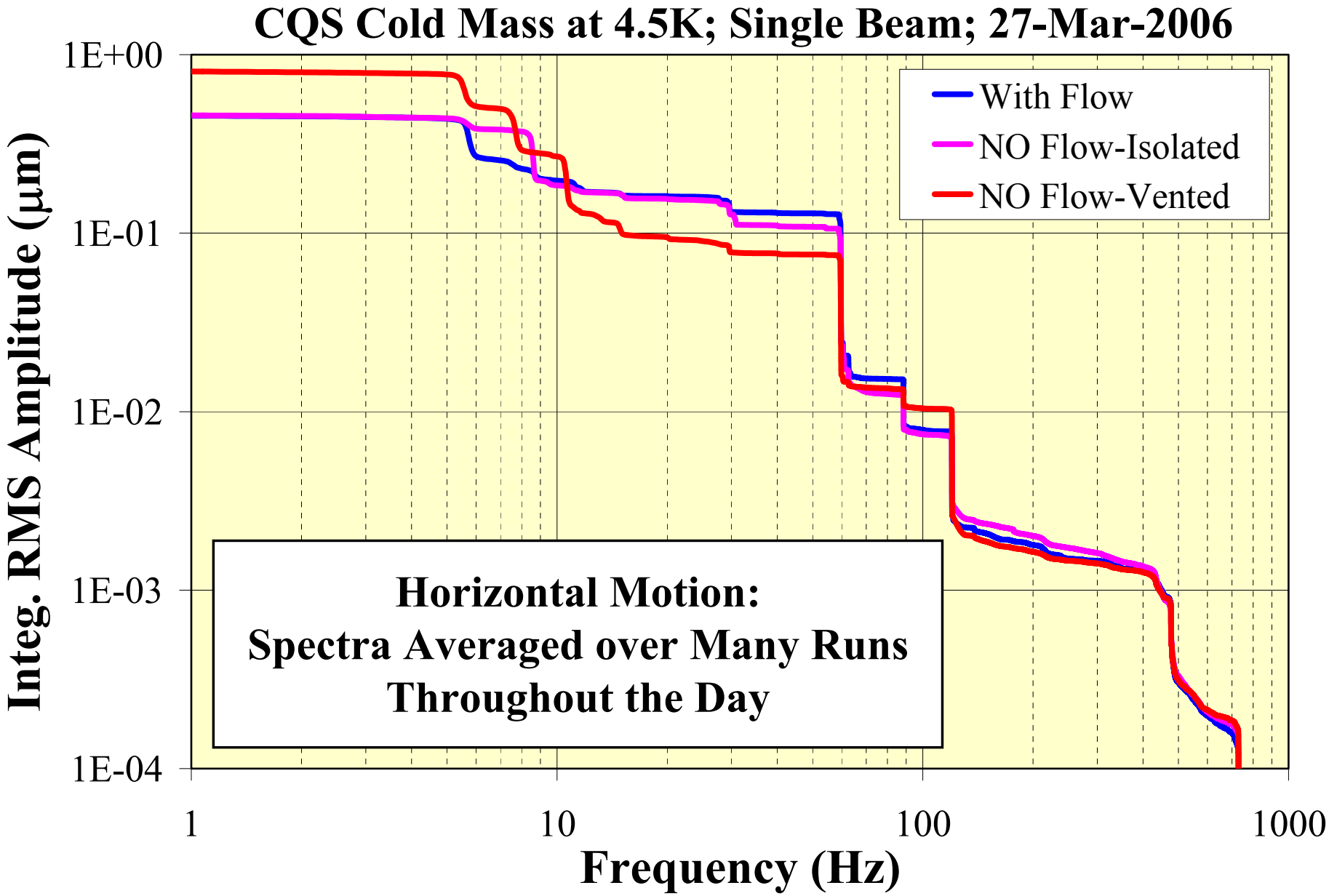
Laser Single Beam (Stabilized) on Cold Mass: 21 Mar'06

RMS Motion: 95.0 Hz to 130.0 Hz



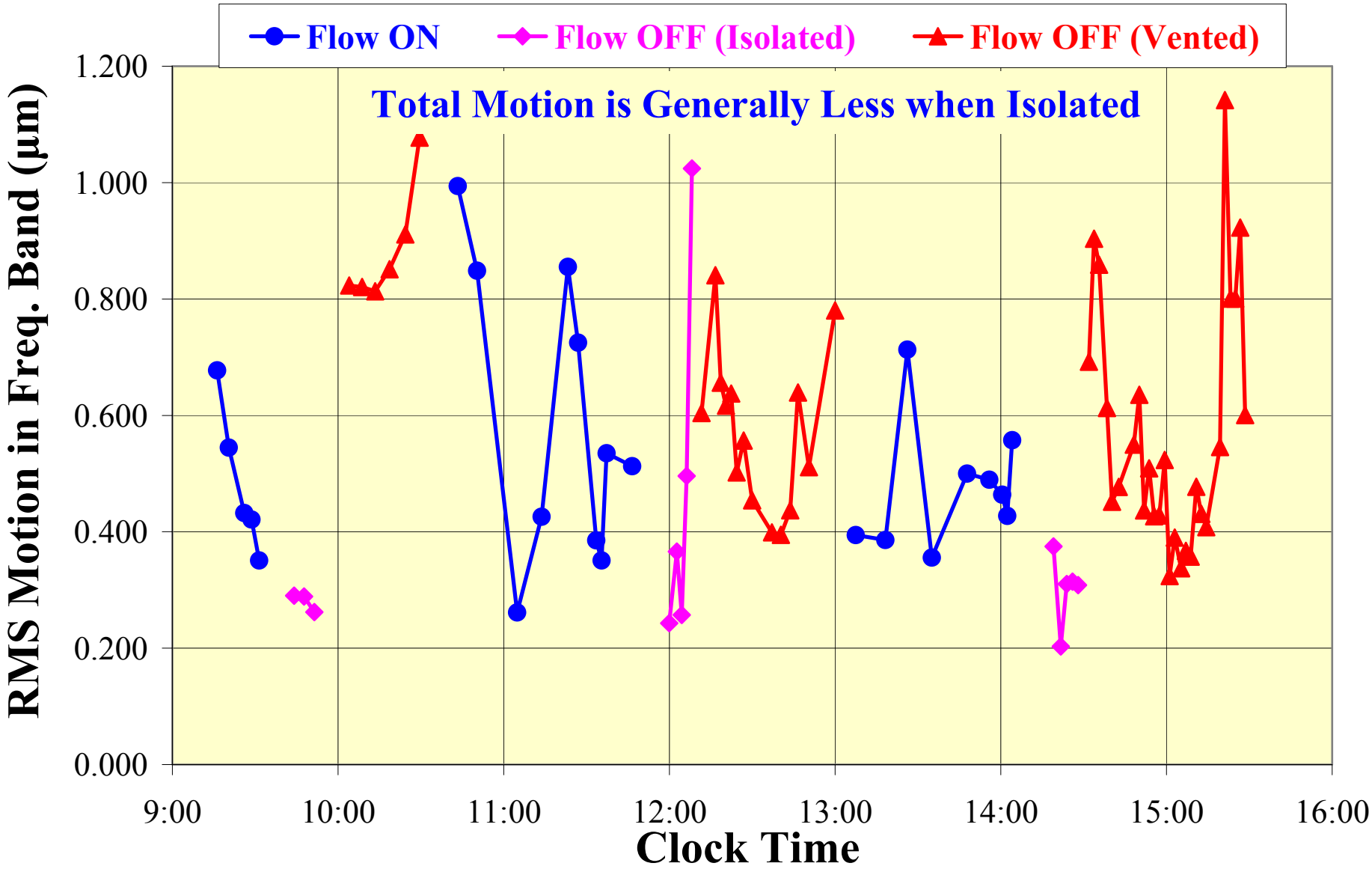
Observations from 21-Mar-2006 Runs

- The motion with flow ON is generally ***less*** than with flow OFF, except for the 60 Hz peak.
- Considerable variation was found over time, sometimes by as much as a factor of two.
- A very large peak appears at ~11 Hz when the flow is stopped. The origin was not understood.
- It was decided to repeat the measurements, with data taken almost continuously, and with the magnet either isolated completely, or vented to the return line, when the flow was stopped. (Done on 27-Mar-2006)
- The helium pressure in the magnet was also recorded along with the vibration data on 27- Mar-2006.


CQS Cold Mass at 4.5K; Single Beam; 27-Mar-2006
Integ. RMS Amplitude (µm)
1E+00
1E-01
1E-02
1E-03
1E-04
1
10
100
1000
Frequency (Hz)
With Flow
NO Flow-Isolated
NO Flow-Vented
Horizontal Motion:
Spectra Averaged over Many Runs
Throughout the Day

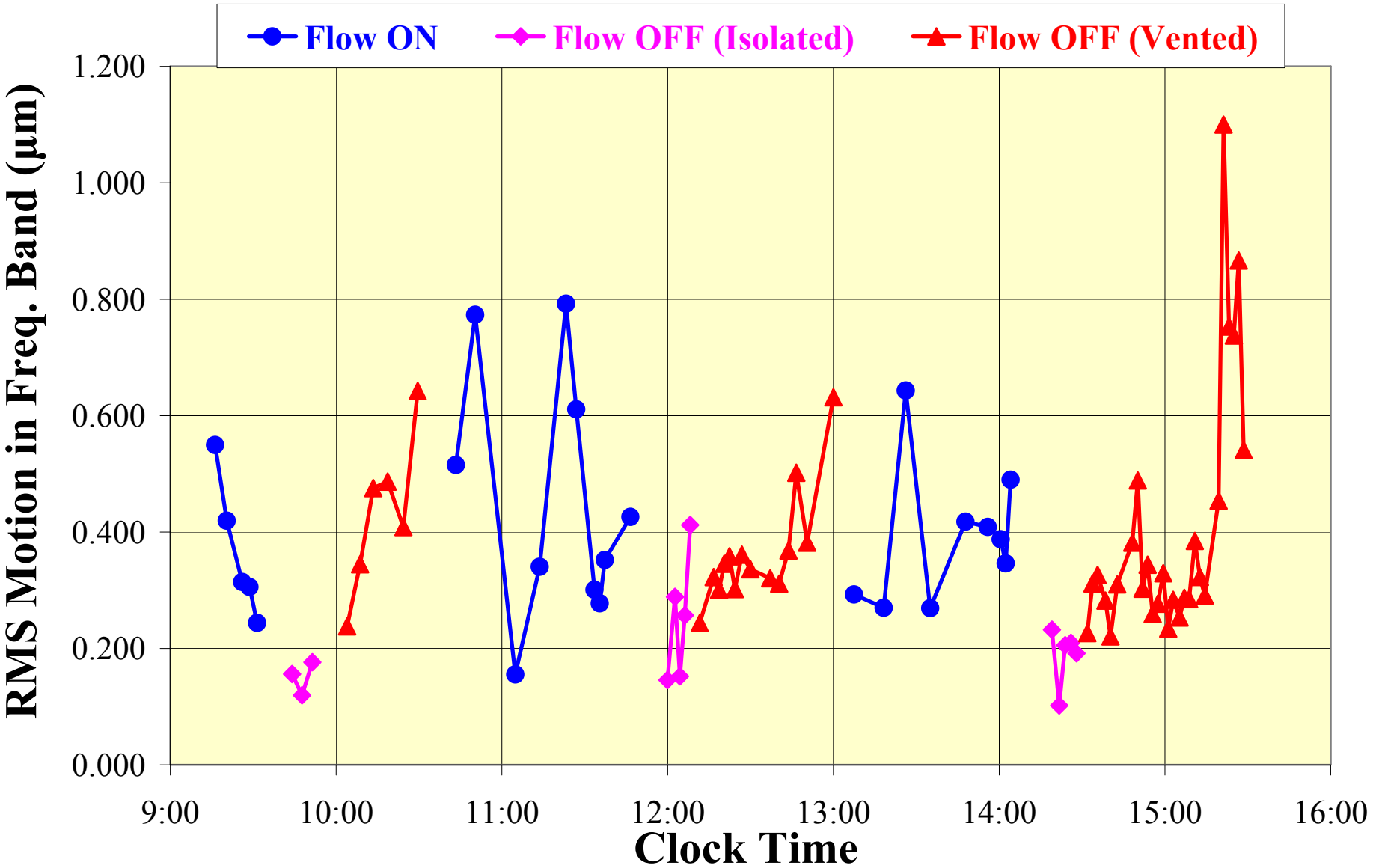
Laser Single Beam (Stabilized) on Cold Mass: 27 Mar'06

RMS Motion: 1.0 Hz to 799.9



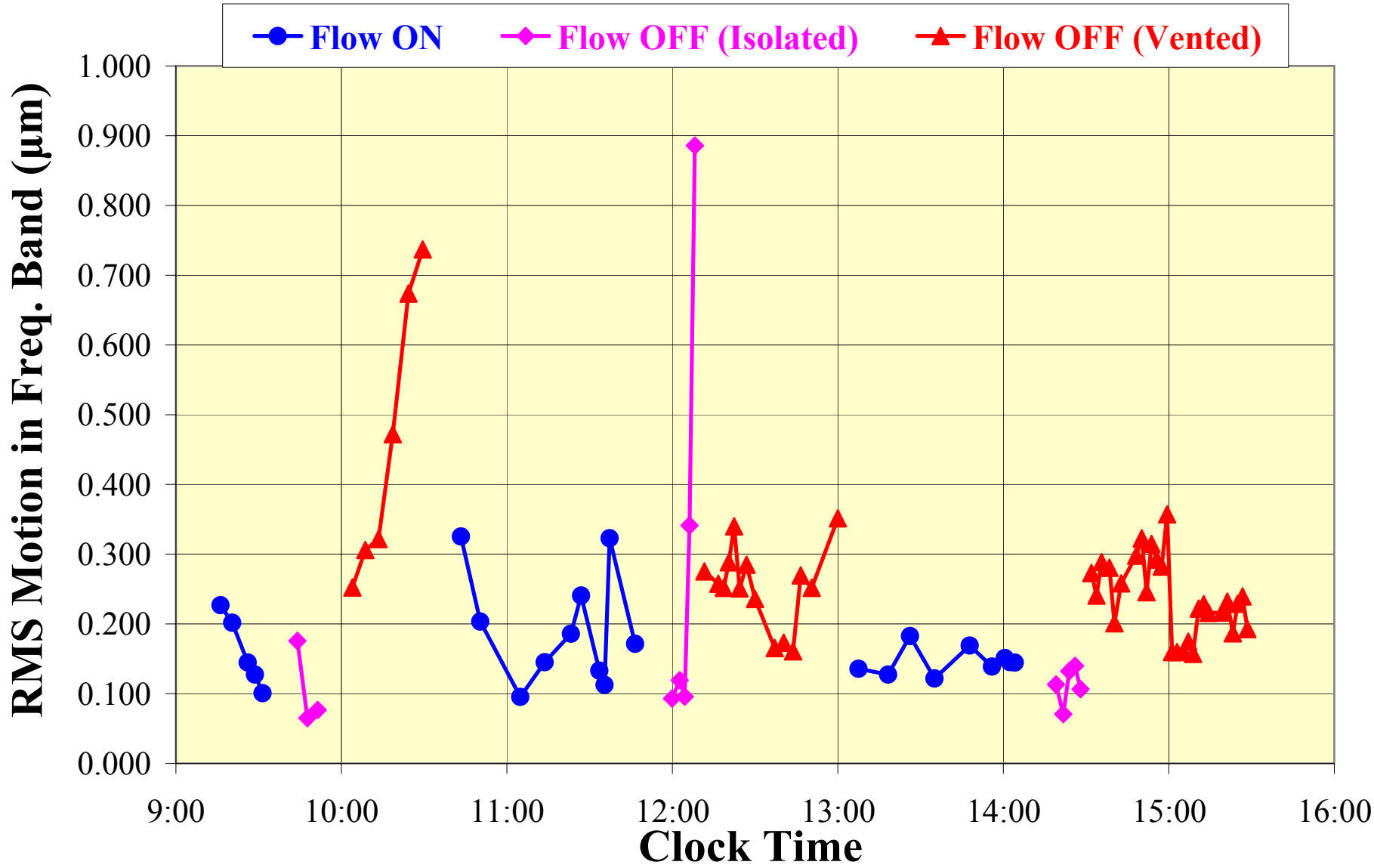
Laser Single Beam (Stabilized) on Cold Mass: 27 Mar'06

RMS Motion: 4.5 Hz to 6.5 Hz



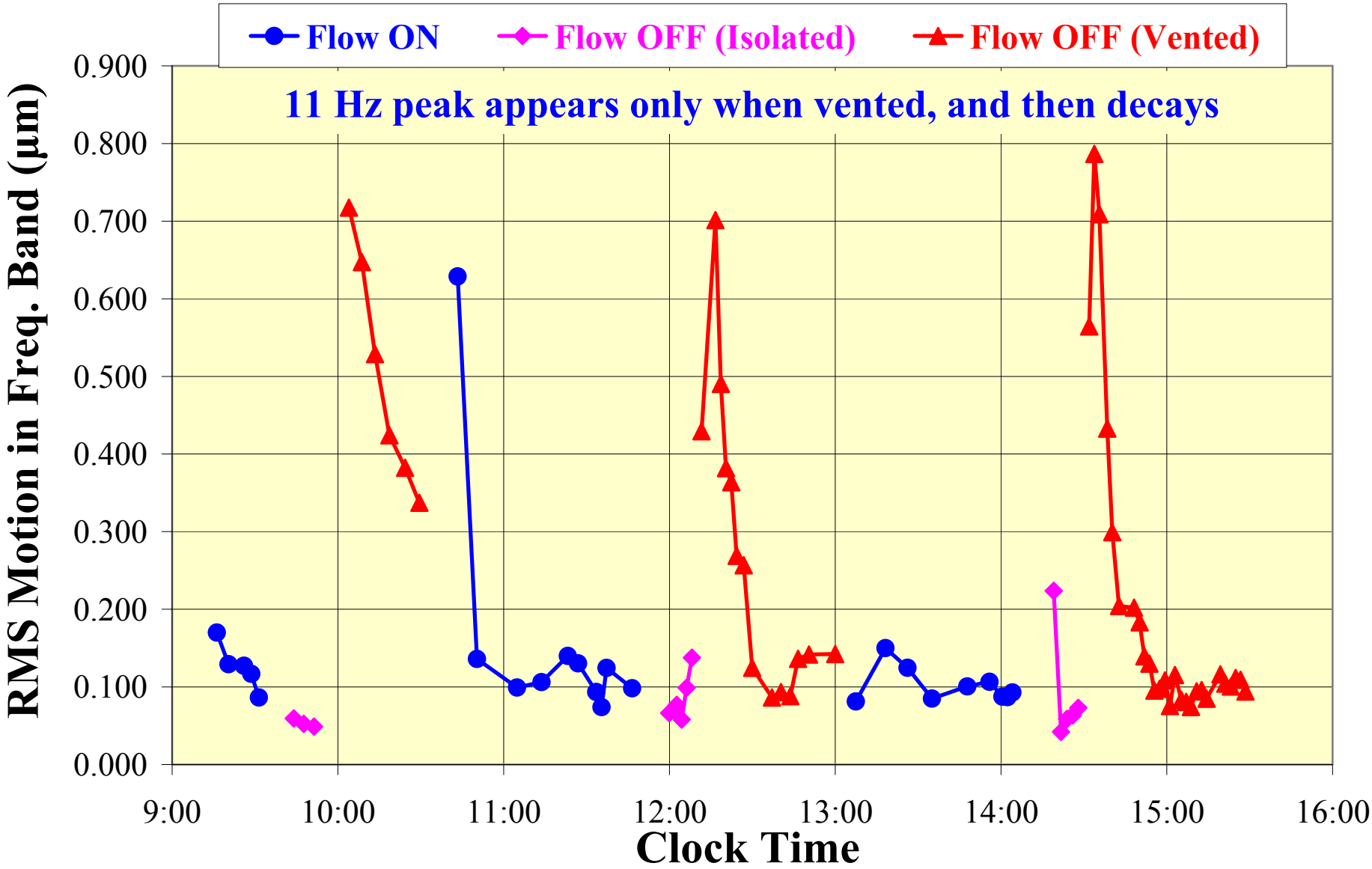
Laser Single Beam (Stabilized) on Cold Mass: 27 Mar'06

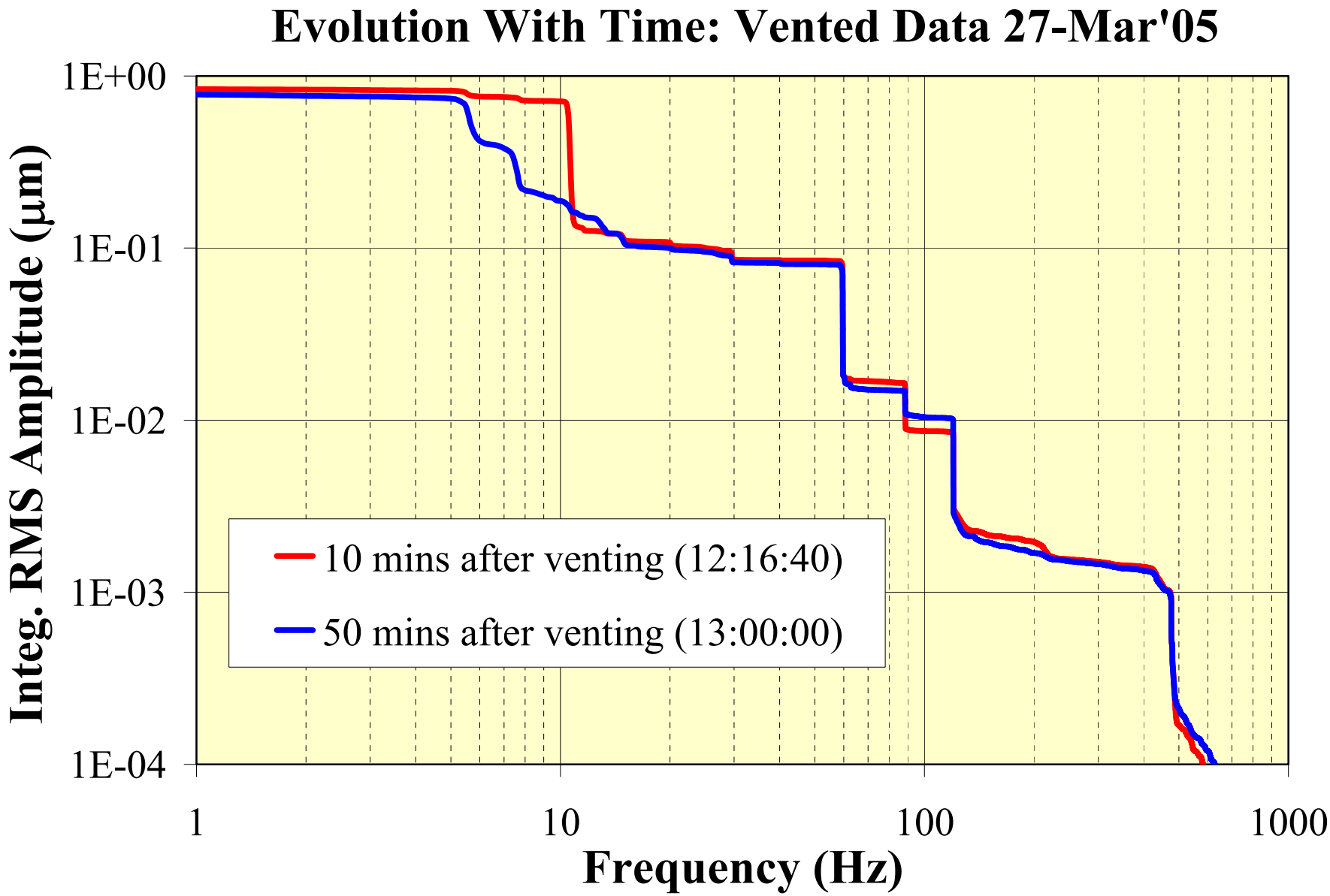
RMS Motion: 6.5 Hz to 10.0 Hz



Laser Single Beam (Stabilized) on Cold Mass: 27 Mar'06

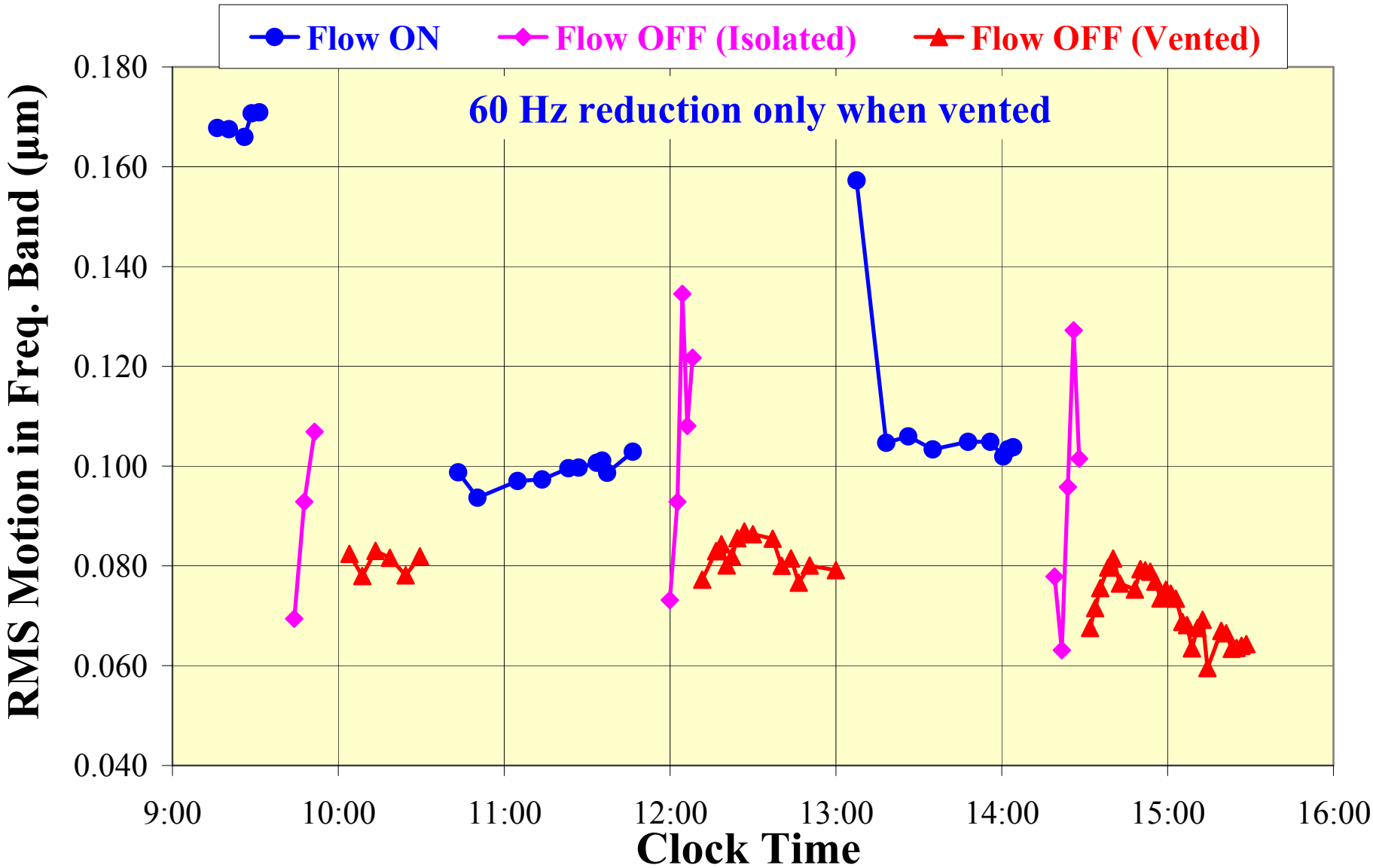
RMS Motion: 10.0 Hz to 13.5




Evolution With Time: Vented Data 27-Mar'05
Integ. RMS Amplitude (μm)
1E+00
1E-01
1E-02
1E-03
1E-04
1
10
100
1000
Frequency (Hz)
10 mins after venting (12:16:40)
50 mins after venting (13:00:00)

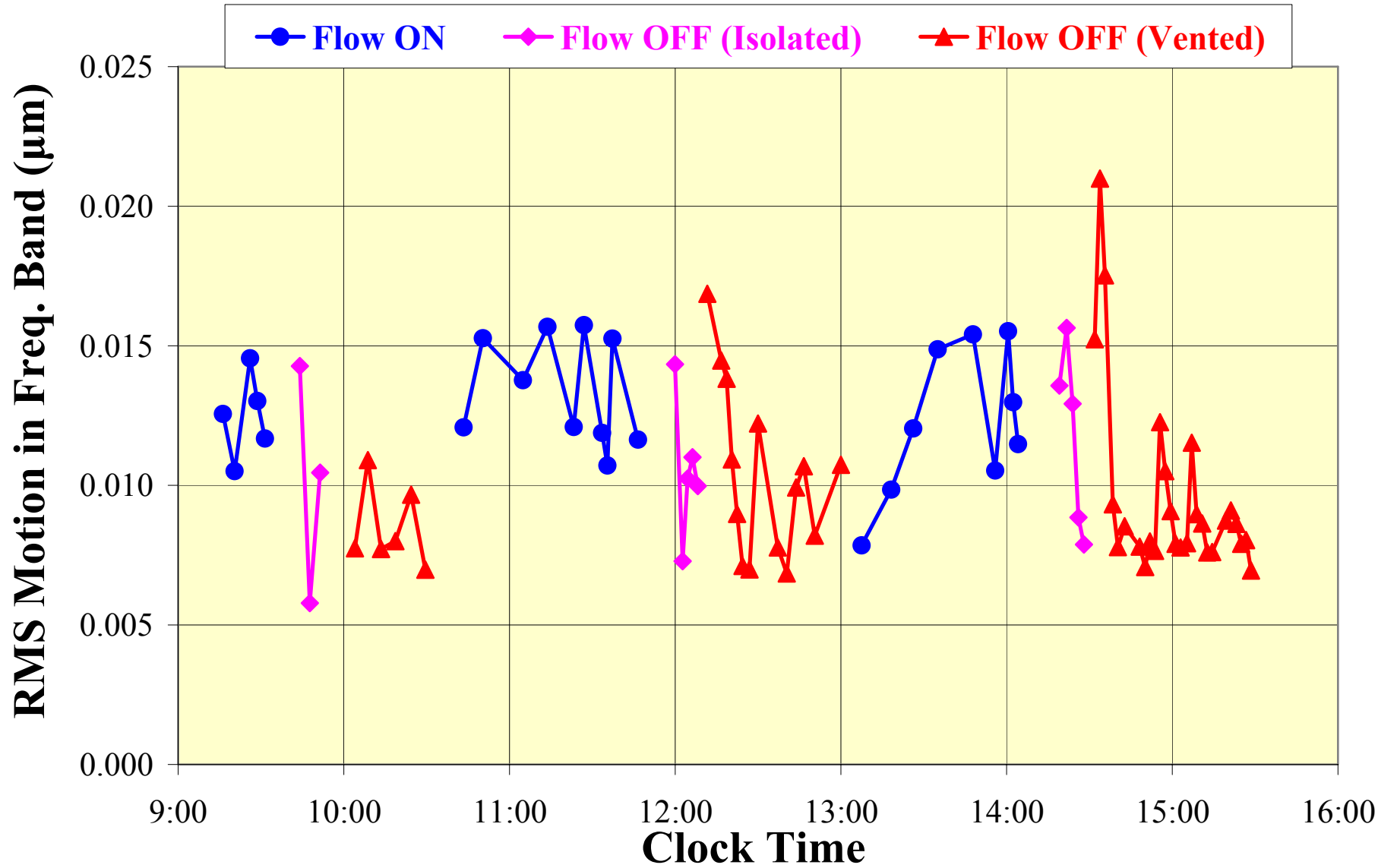
Laser Single Beam (Stabilized) on Cold Mass: 27 Mar'06

RMS Motion: 45.0 Hz to 70.0



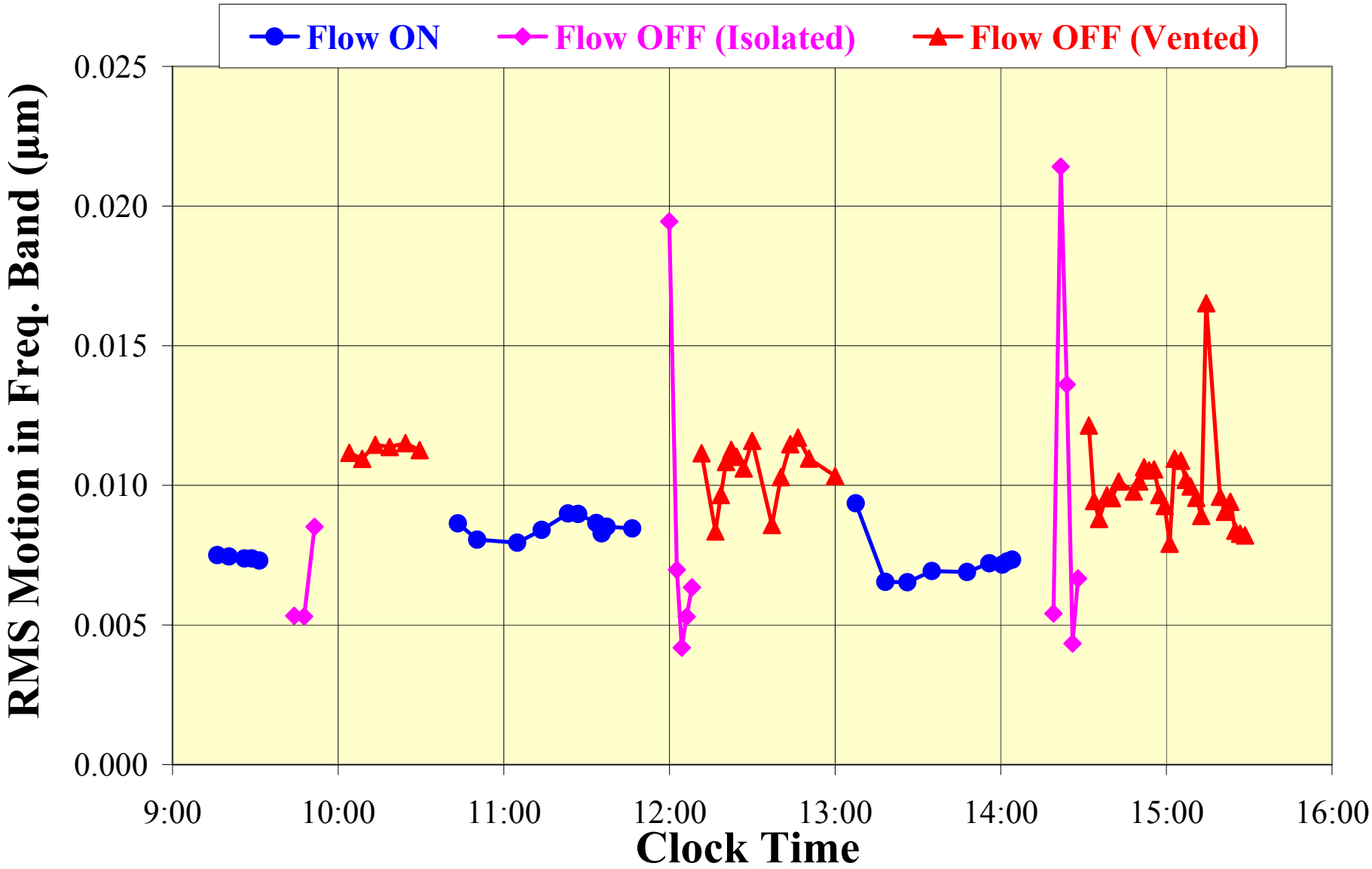
Laser Single Beam (Stabilized) on Cold Mass: 27 Mar'06

RMS Motion: 70.0 Hz to 95.0

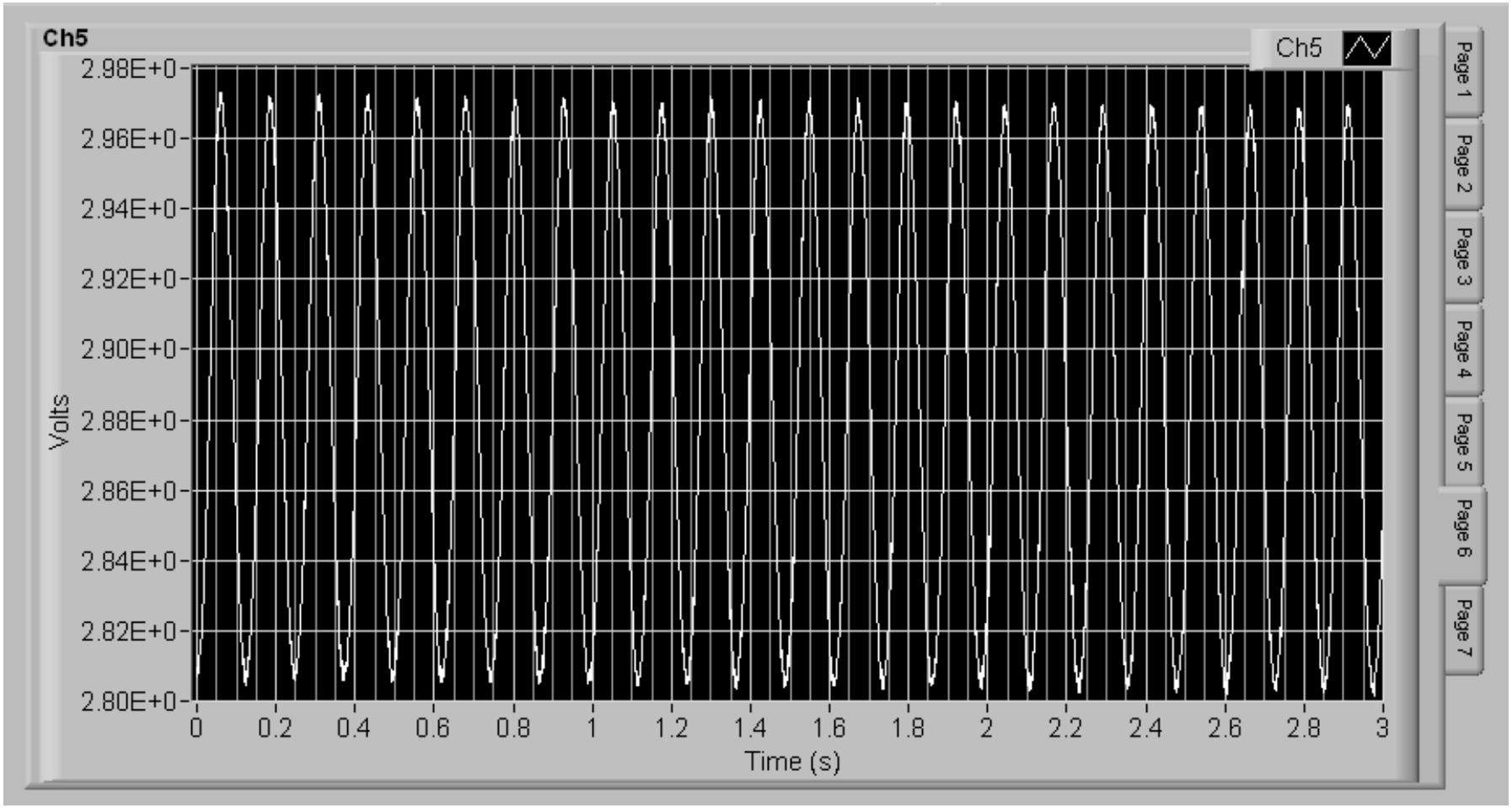


Laser Single Beam (Stabilized) on Cold Mass: 27 Mar'06

RMS Motion: 95.0 Hz to 130.0

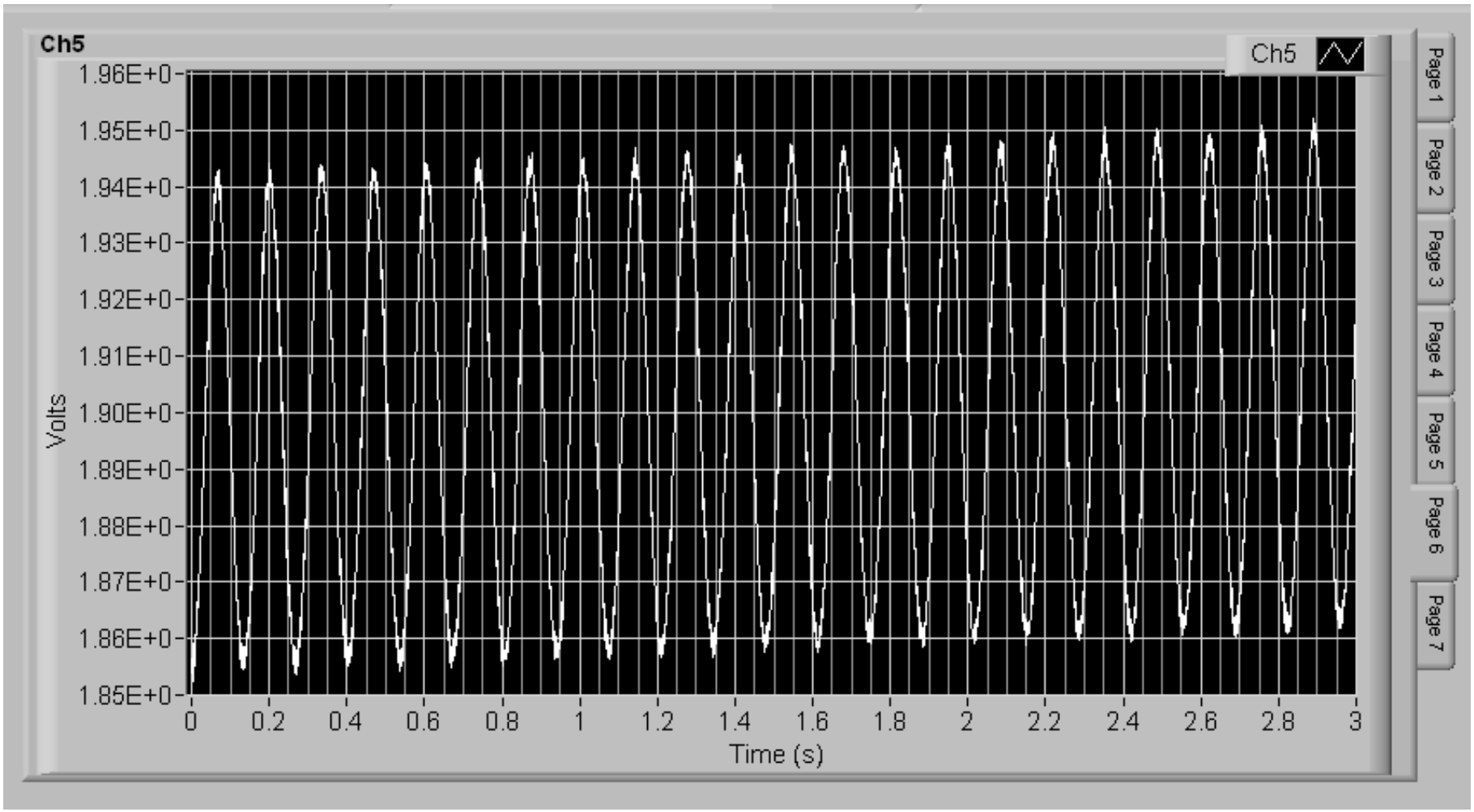


Typical Pressure Data: Flow ON



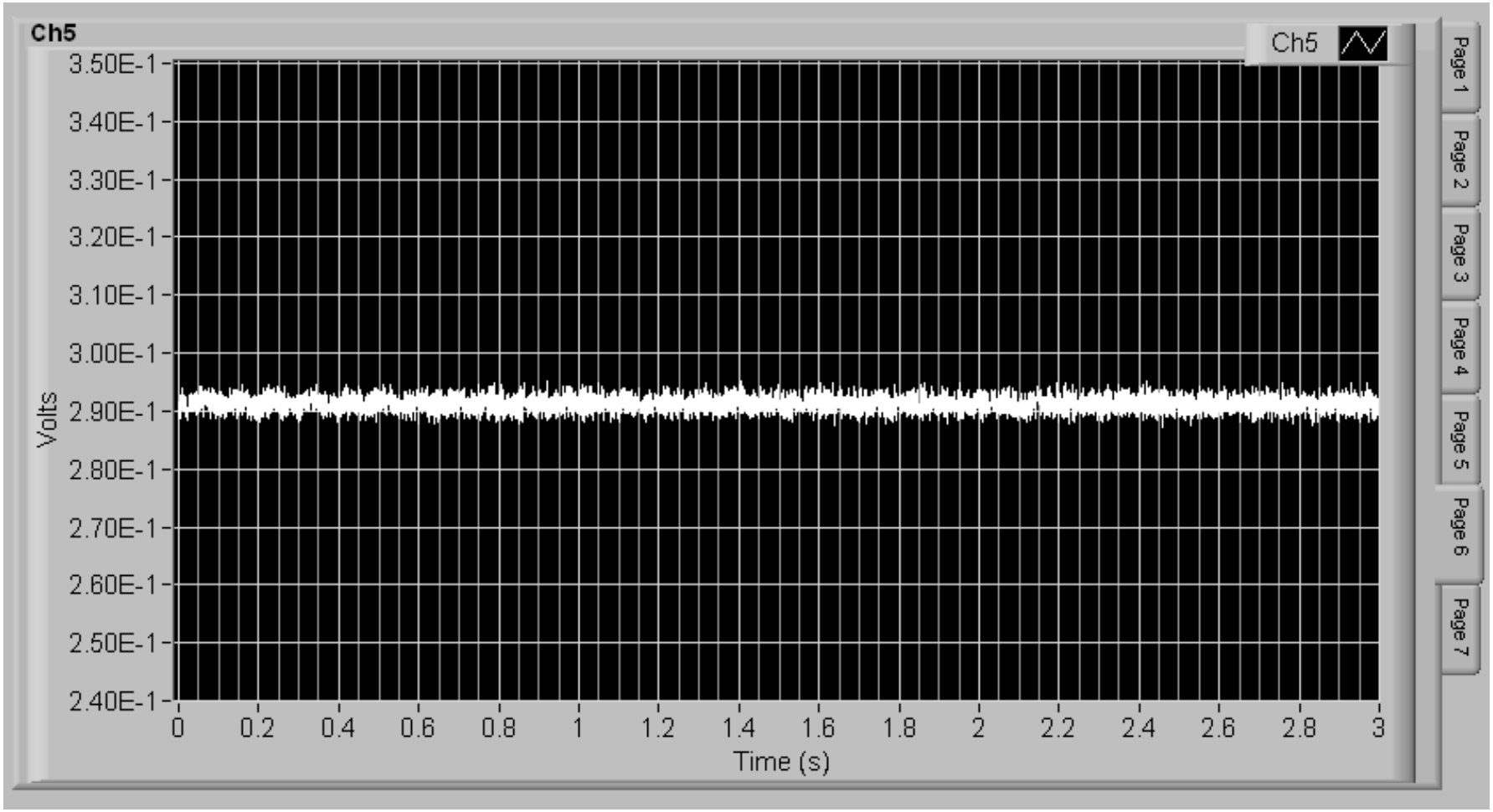
8 Hz oscillations; ~ 10 psi variation peak to peak

Typical Pressure Data: Flow Off, Isolated



7.5 Hz oscillations; ~ 5 psi variation peak to peak

Typical Pressure Data: Flow Off, Vented



No Noticeable Oscillations

Summary

- Separating laser holder from the test stand has resulted in smaller horizontal motion of the holder.
- Active stabilization system reduced the laser head motion enough that single beam mode is quite reliable, at least above ~5 Hz.
- When the helium flow is stopped, but the magnet is not vented, the motion reduces somewhat in nearly all frequency bands.
- When the helium is vented, a strong peak shows up at ~11 Hz, but this motion decays with time.
- The improved resolution of these measurements has clearly demonstrated the effect of cryogenic operation.