Motion sensitivity tests on various CO2 instruments – May 5, 2011

In here we just look at preliminary results from the 7200 and 7500 Licor units.

1) Setup

Instruments were strapped to a motion table (see Figure 1). All instruments were sampling compressed air with a constant 421 ppmv CO2 concentration. In what follows, 7500 refers to the Licor 7500 unit and 7200 to the Licor 7200 sensor.

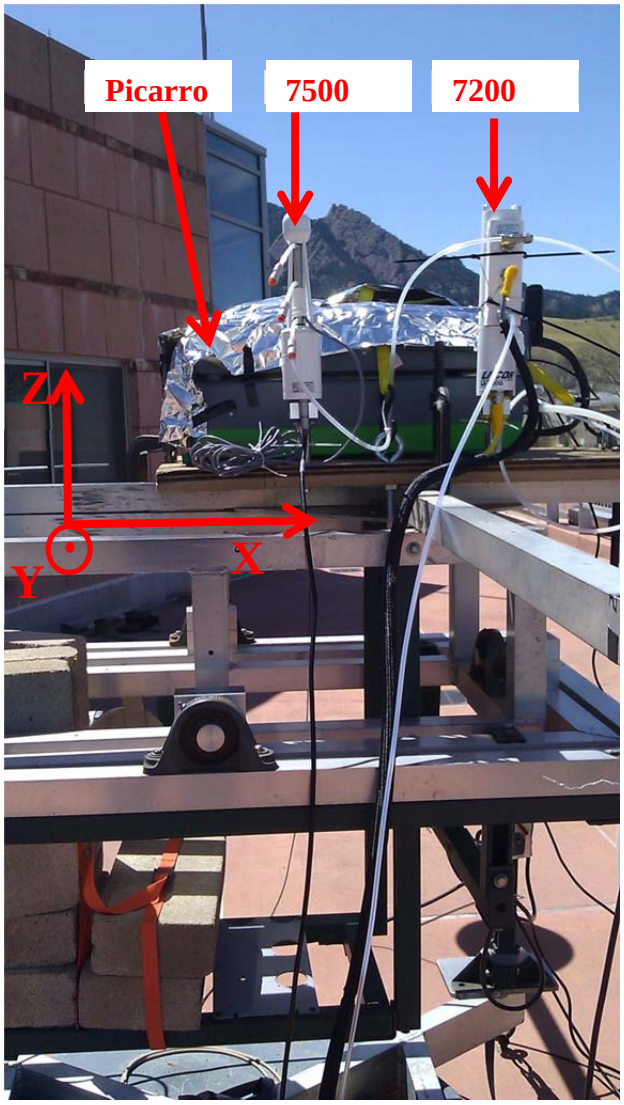

Figure 1: Instruments mounted on motion table.

2) Method

Two different tests were performed due to a problem with the Picarro acquisition.

- In the first test, all instruments were sampling CO2 in series in the following order: Picarro, 7200 and 7500. Three motion tests were performed: pitch (positive for right-hand rotation along Y-axis), roll (positive for right-hand rotation along X-axis), and yaw (positive for right-hand rotation along Z-axis). These tests were performed for about 20 minutes, with zero motion periods in between.

1938UTC: start pitch motion
2002UTC: no motion
2024UTC: start roll motion
2049UTC: no motion
2100UTC: yaw motion (manually performed).
2110UTC: stop tests

- The second test was similar to the first except the 7500 was removed off the sampling line and was not included in the test. Two motion tests were performed: pitch and roll for shorter periods of about 10 minutes

2201UTC: start pitch motion
2212UTC: stop pitch motion
2213UTC: start roll motion
2223UTC: stop tests

3) First motion test results

a) Time series

Time series of CO2 are shown in Figure 2. Few things are interesting to note:

- First the 7500 uses the pressure and temperature measurements from the electronic box. If we use the measurements from the 7200 head instead, we get closer to 421 ppm, and the noise is reduced.
- The noise level in the 7200 appears slightly higher too. It could come from the temperature/pressure measurements. This needs to be looked at.
- For some reasons I don't fully understand yet, the 7500 mean state seems to oscillate more than the 7200. It could be due to the fact that we were using the calibration tube into the

measurement path of the 7500 and it might not have been perfectly sealed. I can do more tests in the lab to check that out.

- The 7500 appears to be more sensitive to pitch motion than the 7200.

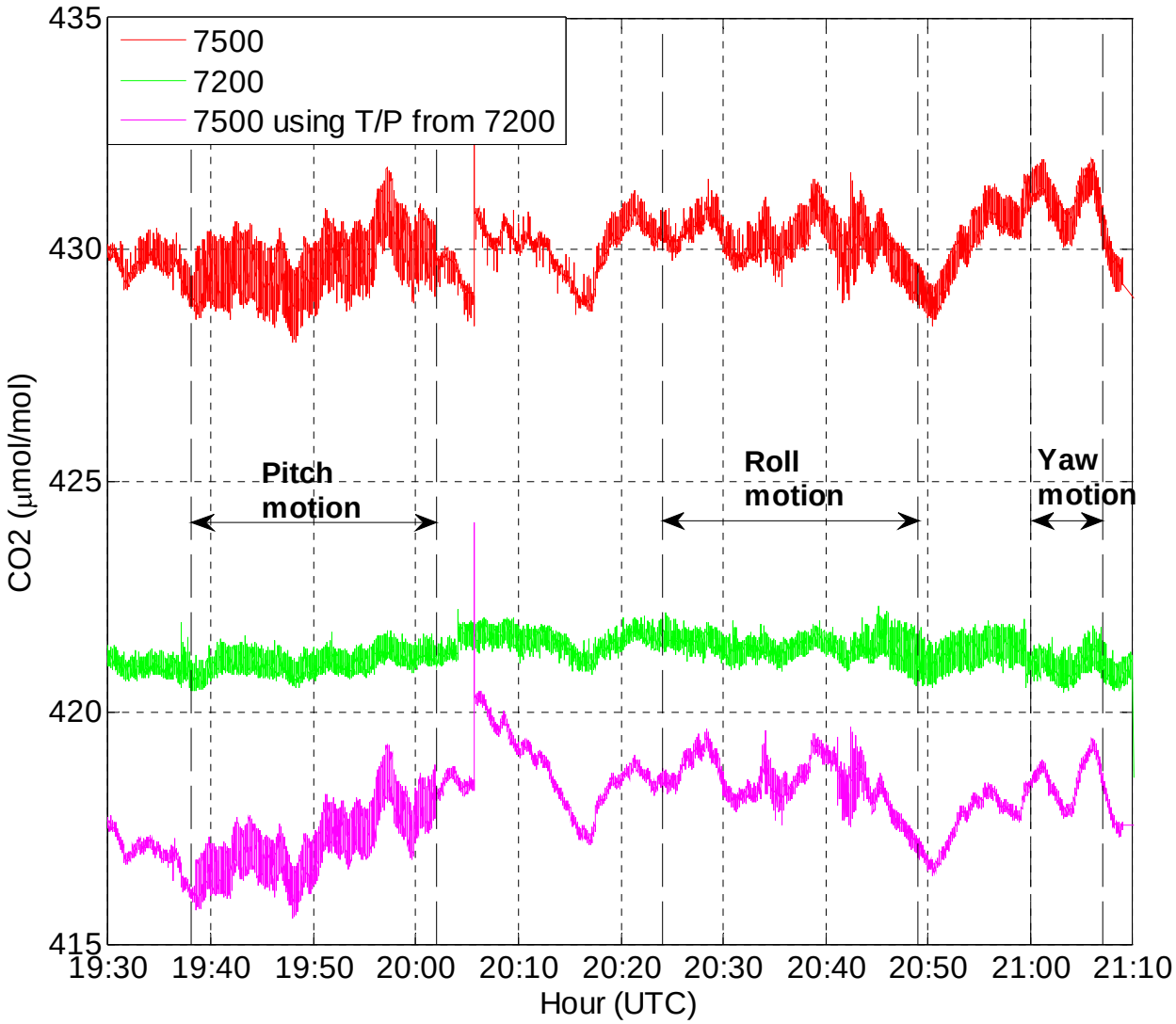

Figure 2: Time series CO2 during first motion test. Red is the output from the Licor 7500, green is from the Licor 7200, and magenta is the 7500 corrected using the pressure and temperature measurements inside the cell of the 7200.

b) Spectra

As seen on Figures 3 and 4, the table generates motion frequencies similar as on a ship (0.1 to 0.3Hz). The 7500 has a relatively huge issue with the pitch, while the yaw has almost no effects. The angles generated by the platform are also relatively large and should not be encountered on a ship (hopefully). See angles during second test (Figure 7). I am still awaiting first motion data set from Alan.

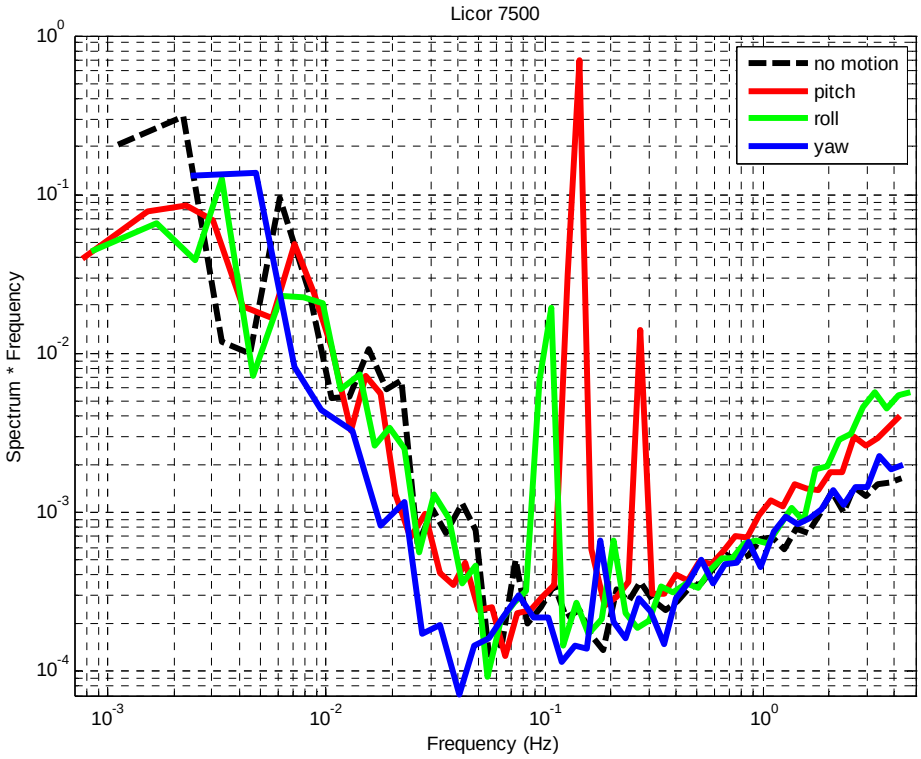

Figure 3: Normalized variance spectra of CO2 for the Licor 7500 during first test.

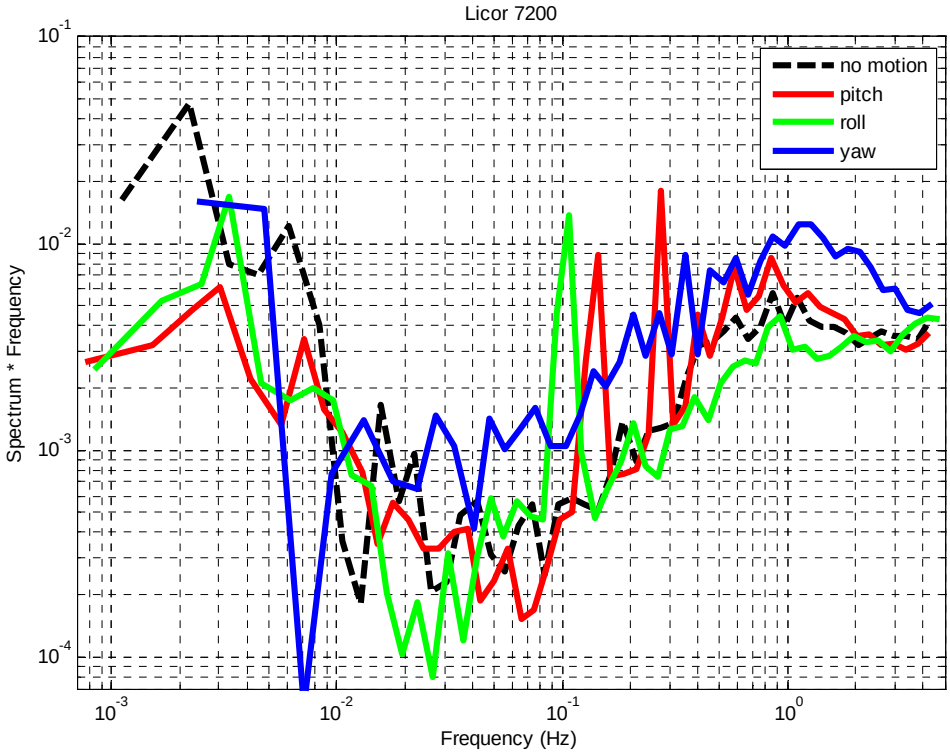

Figure 4: Normalized variance spectra of CO2 for the Licor 7200 during first test.

4) Second motion test results

Similarly to the first test, we plot the time series (Figure 5) and variance spectra (Figure 6) of the Licor 7200. We see similar results except for some reasons the spikes due to the pitch seem to have grown, and this especially for the ones at .4 and .7Hz. This could be due to a slightly different motion than previous test (maybe the levels had changed a bit).

From second motion data set, we can observe relatively large angles of the motion table (Figure 7).

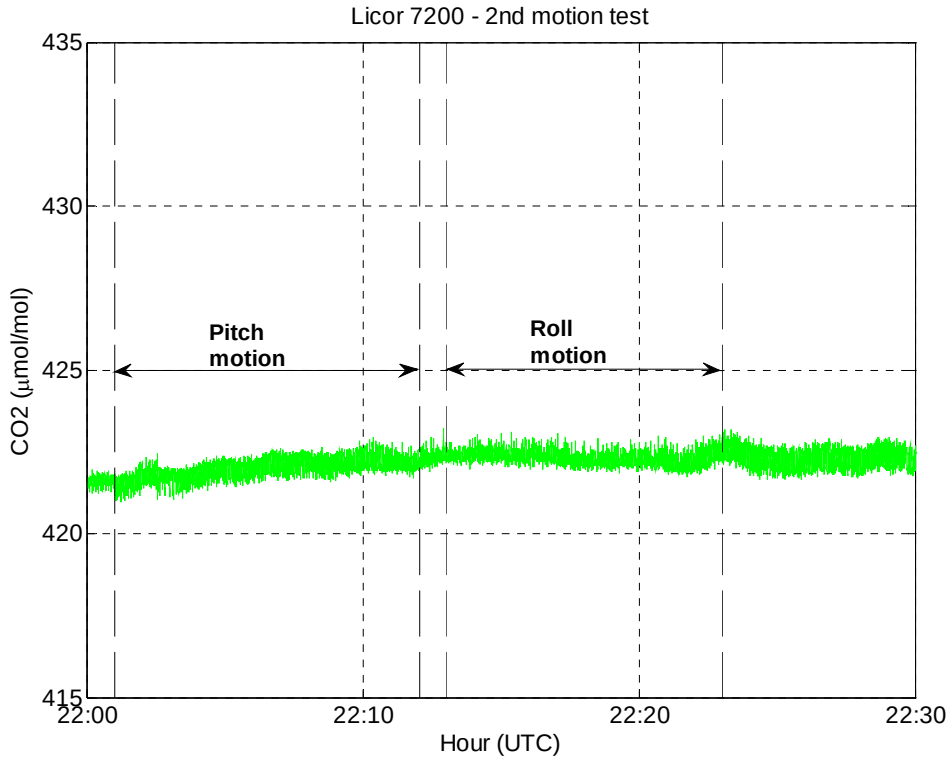

Figure 5: Time series of CO2 during second motion test (7200 only).

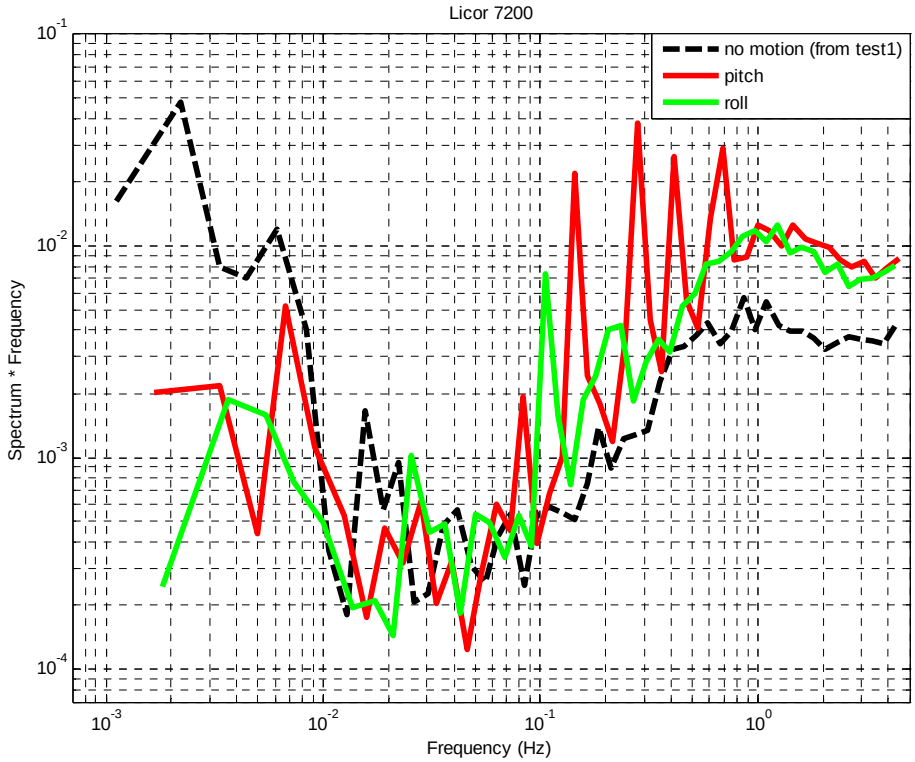

Figure 4: Normalized variance spectra of CO2 for the Licor 7200 during second test.

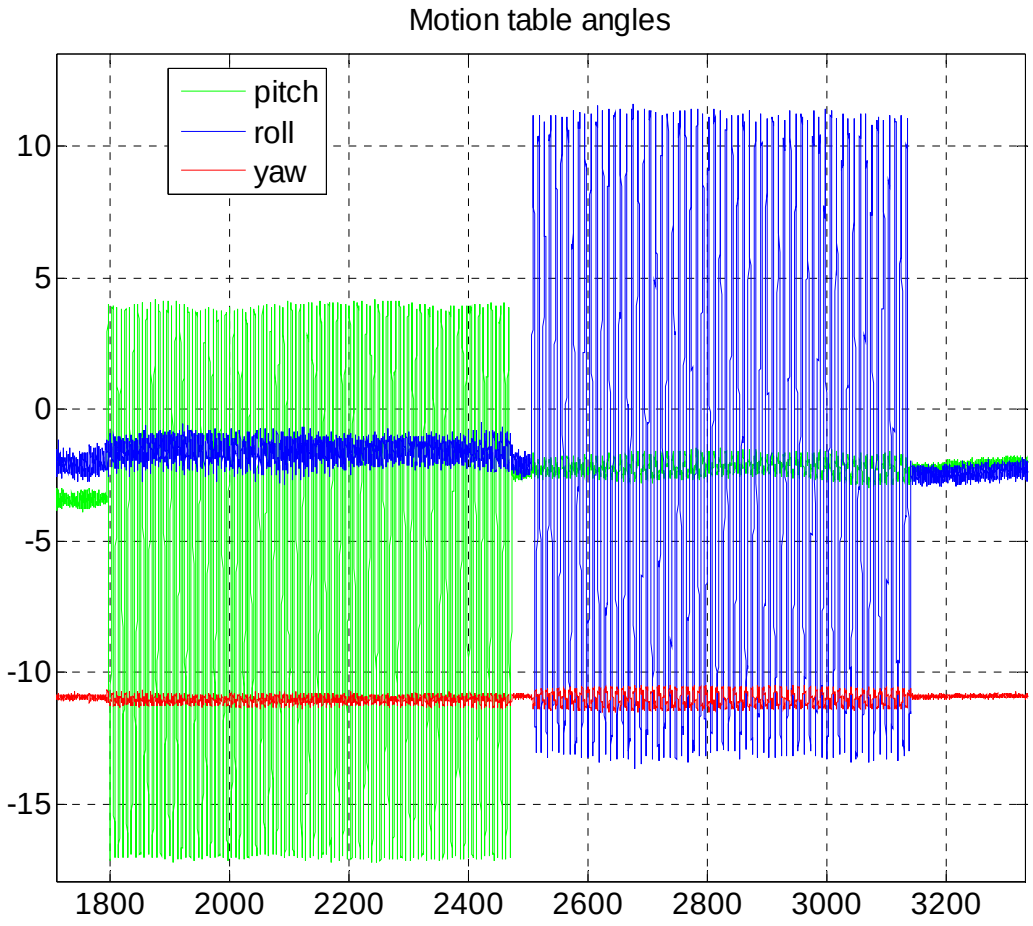

Figure 7: Pitch, roll and yaw from the differential GPS during second test.

5) Flow controller and LI7200 other parameters

The 7200 uses two thermocouples to measure the inlet/outlet temperatures. During the test the inlet temperature thermocouple got damaged. Previous test in the lab were fine but for some unknown reasons yet this thermocouple broke. It can come from the use of a smaller connector diameter which could create a jet flow type at the inlet. One suggestion by Byron is to replace those thermocouples by stronger ones.

The Licor uses in its calculations a weighted average of the two measurements (20% T_in + 80% T_out from calculation). The question is how the 7200 computes the mol fraction when a problem occurs. We could always use the Mass Flow Controller (MFC) has a backup if needed. However on that test, the difference in temperature was about 2 degC (Figure 8). It could come from that fact that the MFC was in the shade, while the 7200 head wasn't. The two measurements were separated by about 7m in the line (they will be much closer during deployment).

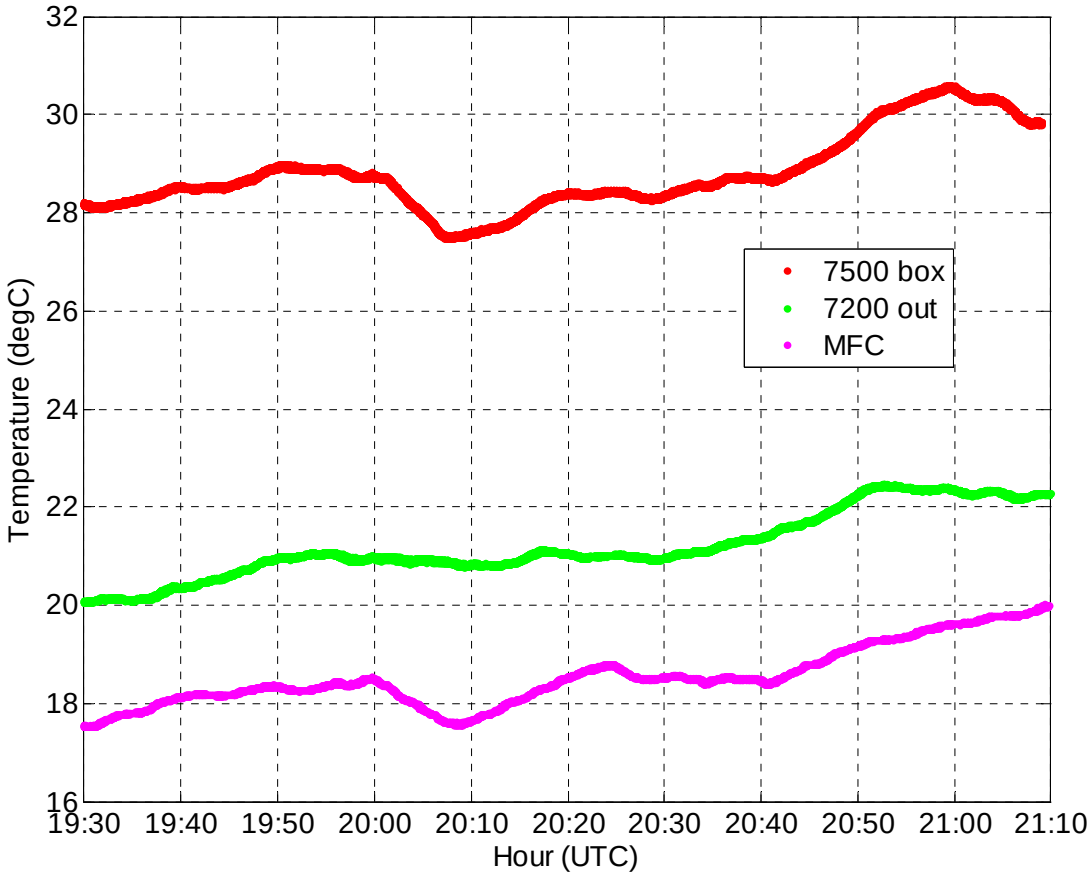

Figure 8: Time series of temperatures. Red is from the Licor 7500 box, green is from the Licor 7200, and magenta is the Mass Flow Controller.

We can say that the motion effects on the Licor will occur mostly on the chopper filter wheel. Looking at the spectra of differential pressure sensor inside the 7200 head (figure 9), one can see that similarly to the Picarro, the motion due play a role on the pressure measurement. The question is to know if it's coming from the sensor itself or if it's a real signal, i.e a pressure fluctuation at the inlet? The former is probably more plausible.

Another test to do would be to put the MFC on the motion table and see if this comes in play or not, i.e is the MFC affected by motion?

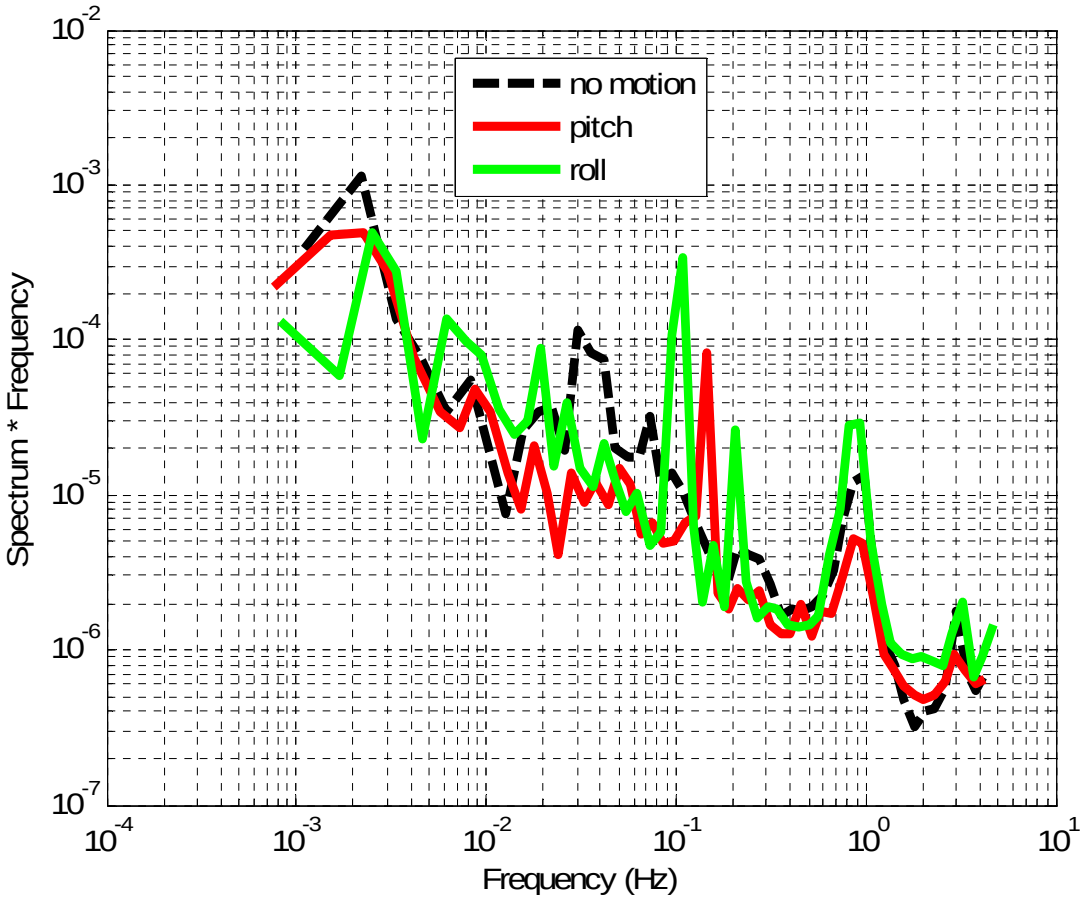

Figure 9. Normalized variance spectra of head pressure for the Licor 7200 during first test.