

## **Appendix C**

### **LDV Operation and Testing Procedure**

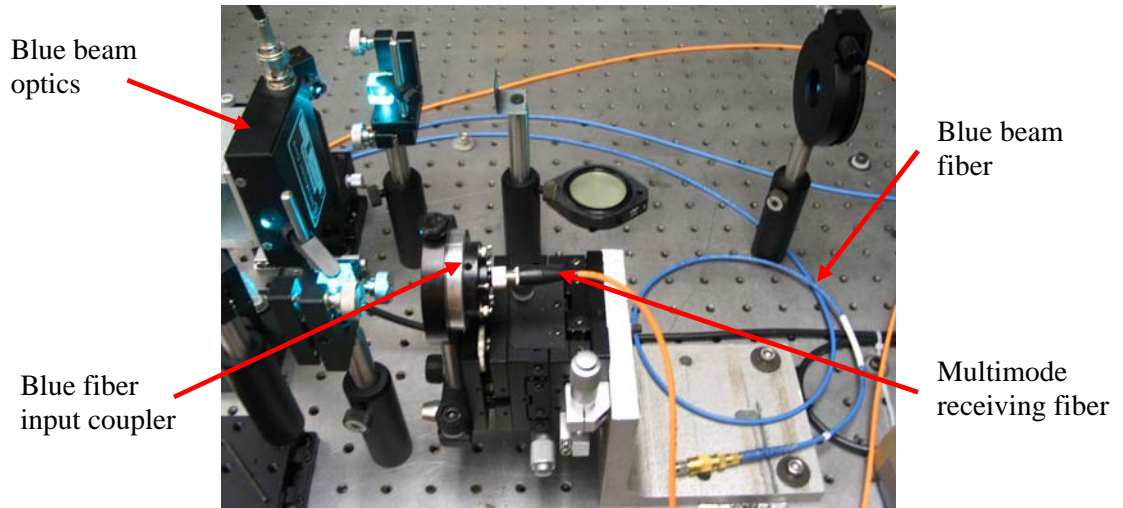
The procedures used to operate the LDV and prepare it for measurement are presented in this appendix. Before making measurements with the LDV, the optical system must be aligned and optimized, and the electronics must be configured. The following procedures are written with the assumption that the reader has all necessary equipment set up and properly functioning.

#### **C.1 Optical System Alignment and Optimization**

If all of the optical components of the LDV are protected and treated carefully, the following daily alignment and optimization procedure will be sufficient to provide consistently successful LDV measurements. If a large misalignment is encountered anywhere in the optical system, it must be at least coarsely corrected before execution of the following procedure. Procedures to correct large misalignments can be found in references [5] and [6].

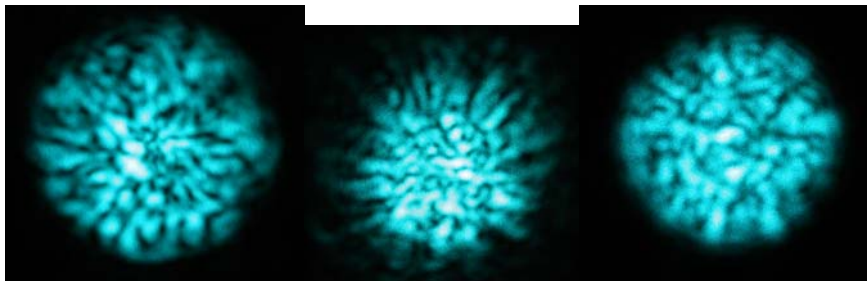
1. Turn on laser head and allow one hour for warm up.
2. After warm up period, use horizontal and vertical rear reflector controls on the laser head to optimize the laser power output. Figure A-1 illustrates these controls. The laser power can be read on the front panel of the laser power supply, or for a more accurate measurement, a stand-alone laser power meter can be installed in front of the laser head.
3. Remove the blue beam fiber from the fiber coupler at its input end and screw a protective cap on to the fiber. Also, remove the receiving optics fiber from the coupler on the PMT box.

4. Connect the disconnected receiving fiber to the blue fiber coupler as shown in Figure C-1. This will direct the blue beam out through the receiving optics for alignment.



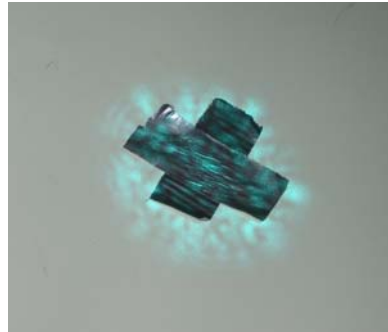
**Figure C-1.** Connect multi-mode receiving fiber to the blue fiber input coupler.

5. Block the green beam before it enters the green beam fiber.
6. Place the microscope objective at the focal point of the scattered light collection mirror. Observe the microscope objective output on a screen at least 1 meter away and adjust the location of the objective along the common beam axis until the focal point is found. Figure C-2 illustrates the objective output before, at, and past the focal point.



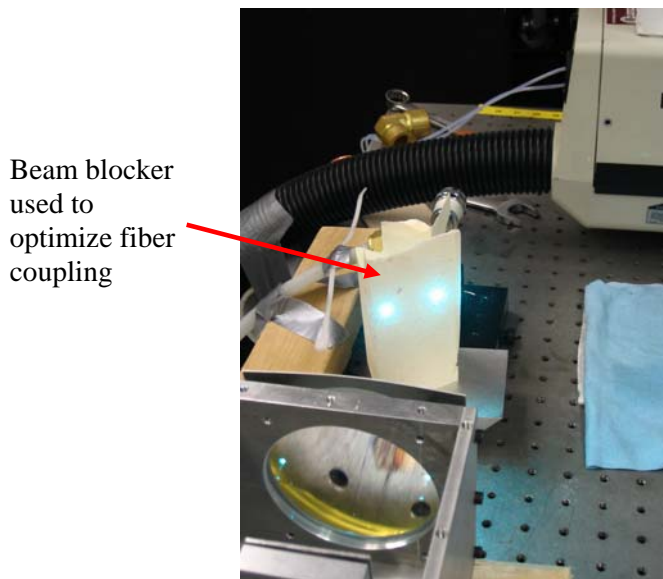
**Figure C-2.** Output of microscope objective before, at, and beyond scattered light collection lens focal point.

7. Once the objective is accurately placed at the focal point of the scattered light collection lens, mark the position of the output spot on the screen. Duct tape is a convenient marker, as shown in Figure C-3. Take care not to move the objective once it is aligned.



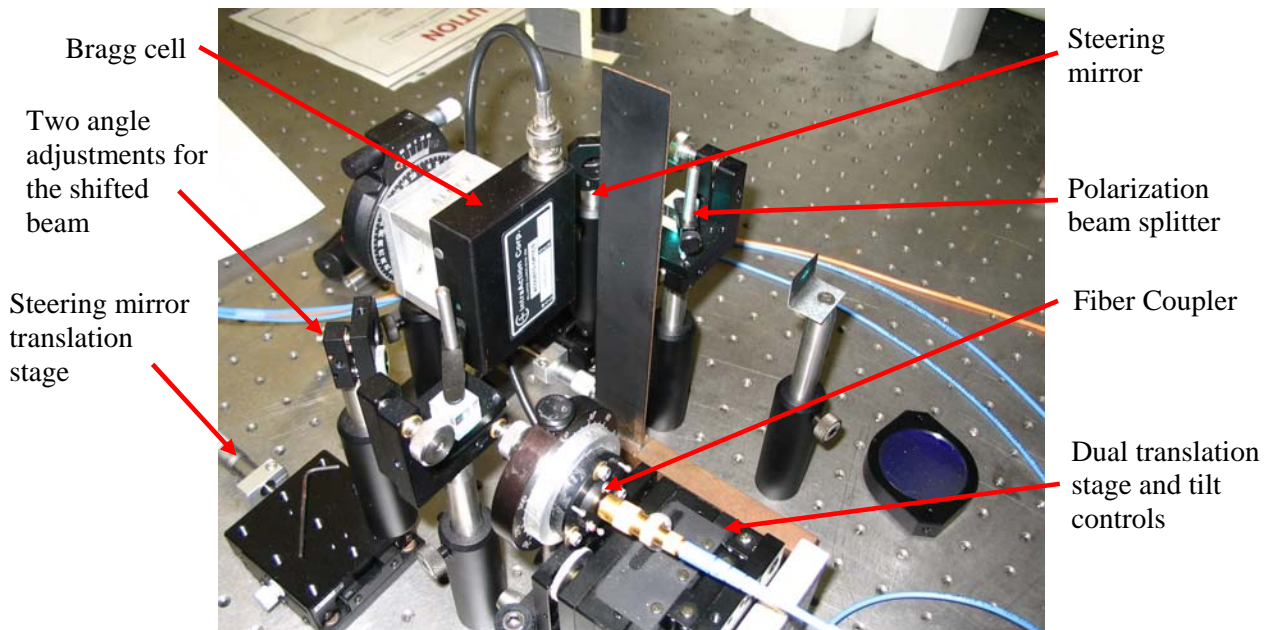
**Figure C-3.** A duct tape x makes a convenient marker for the LDV alignment.

8. Carefully reconnect the multi-mode and blue beam fibers to their original locations.
9. Place a beam blocker between the LDV probe and the objective, as shown in Figure C-4. Also, block the shifted component of the blue beam before it enters the fiber.



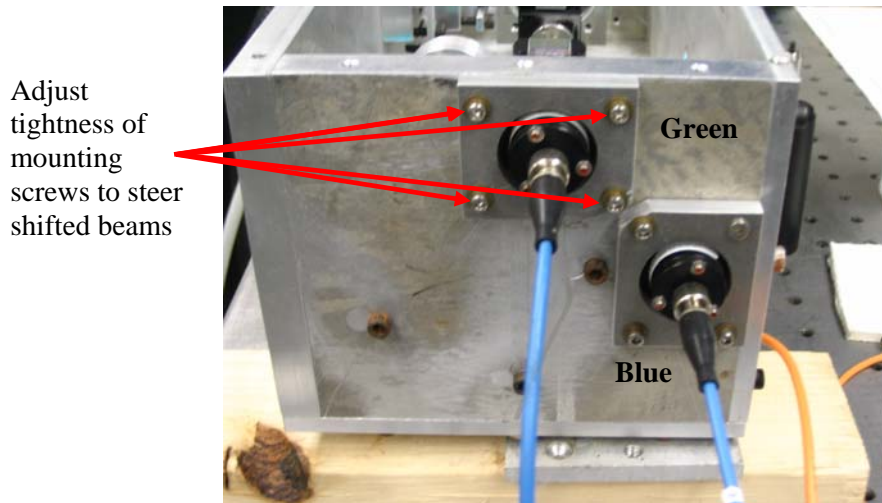
**Figure C-4.** Place a beam blocker between the probe and objective to optimize fiber coupling.

10. Use the blue fiber coupler controls (translation and tilt) to optimize the coupling into the fiber. Adjust each of the controls to maximize the intensity of the reflection from the beam blocker positioned between the probe and objective. Repeat adjustment until every milliwatt of power is coaxed from the beam.
11. Unblock the shifted blue component and block the non-shifted blue component. Optimize the reflected intensity off of the beam blocker, as in step 10, using the mirror controls indicated in Figure C-5. Steps 10 and 11 can be performed either visually, as explained, or using a power meter. The power meter provides the best results but is more time consuming to position and use. With practice, visual optimization can yield results as high as 97% of the maximum attained using the power meter.



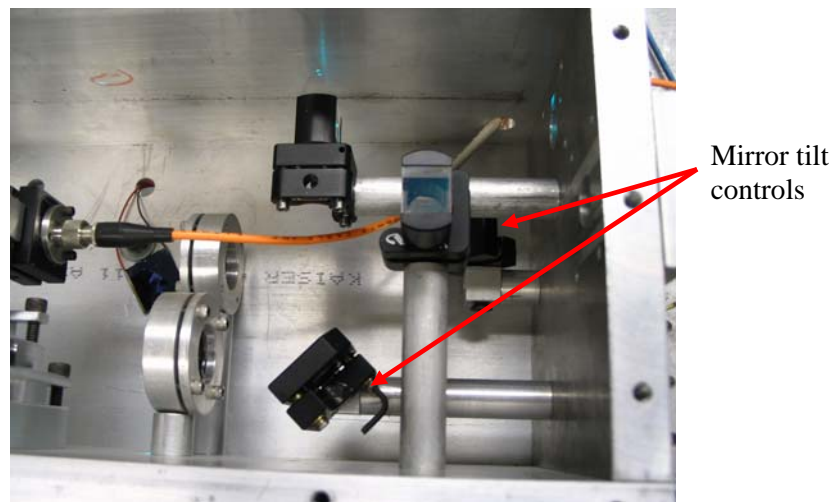
**Figure C-5.** Laser coupling adjustment locations. The components shown are for the blue beam; however, the green components are similar.

12. Remove beam blocker between the probe and objective.
13. Adjust the probe fiber coupler using its mounting screws, as shown in Figure C-6, to center the shifted beam on the spot marked on the screen during step 7.



**Figure C-6.** Adjust coupler mounting screw tightness to steer shifted beams.

14. Unblock the non-shifted beam and block the shifted beam.
15. Use the mirror tilt controls in the probe, as shown in Figure C-7, to center the non-shifted beam.



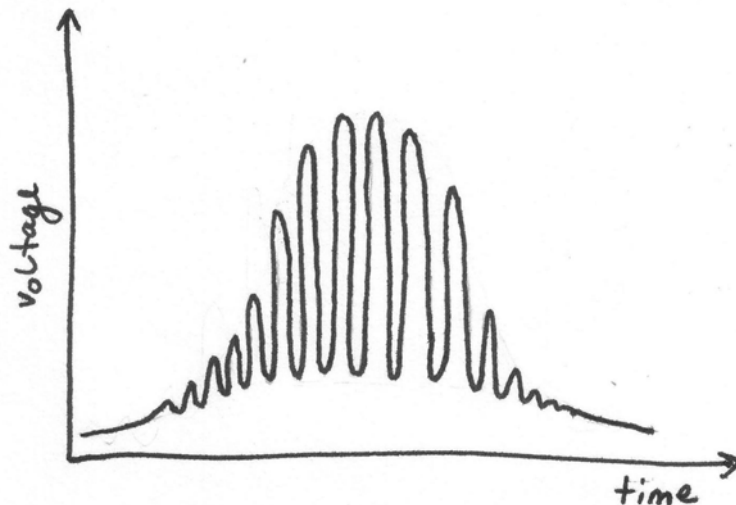
**Figure C-7.** Adjust mirror tilt controls to steer non-shifted beams.

16. Once both the shifted and non-shifted beams are aligned, unblock both beams and look closely at the screen to check for the presence of interference fringes.
17. Block the blue beam and unblock the green beam.
18. Repeat steps 9 through 16 for the green beam.

19. Unblock the blue beam and check for orthogonal fringes from both beam components, as well as collocation of the beams.
20. The optical system is now aligned and optimized for measurement; the microscope objective can be removed.

## C.2 LDV Electronic Hardware Adjustment

1. Turn on all electronic equipment including: high voltage power supply, 'LDV computer,' op-amp power supplies, old LDV electronics box, oscilloscope, and the counter timers.
2. Turn on the air supply to the atomizer, and adjust the tube so that outlet flow passes through the probe volume.
3. Follow the procedure outlined in [4] to set the high and low limit filters on the counter timers. During this procedure, monitor the 'Filtered Out' line on the oscilloscope. With the filters off, a Doppler burst signal will look like the sketch shown in Figure C-8. The high limit filter removed high frequency noise and the low limit filter removes the pedestal component of the Doppler burst.



**Figure C-8.** Sketch of a Doppler burst signal as it comes from the PMT.

4. A PMT supply voltage of 450 has been producing strong results.
5. As described in [4] adjust the cycles/burst control, gain setting, and exponent to optimize data rate, as indicated on the 1992 module of the counter timer.
6. Connect the multiplexer outputs to the oscilloscope and the high speed DAQ board. Connect channel A from the high speed DAQ to the 'Data Ready' trigger signal and channel B to the 'Time' frequency signal. The output is teed off to the oscilloscope at the multiplexer output.
7. Supply the multiplexing relay with 0 Volts to measure the blue signals and then supply the relay with 5 Volts to measure the green signals.

### **C.3 LDV Software Usage**

1. The folder 'H2\_VIs' on the desktop of the 'LDV computer' contains all of the VIs created during this study.
2. Open 'FastLDVCheck.vi' to capture and process a velocity measurement.
3. Enter a valid path and file name such as D:\LDV\_data\green where velocity data is saved.
4. Enter the desired number of iterations, as the number of iterations increases so does the accuracy of the measurement.
5. Check that both sample rates are equal; 10MHz has provided consistently strong results.
6. Set the trigger level, 3.6 works well for green and 3.4 for blue.
7. Enter the exponent setting and cycles per burst from the counter timer settings.
8. To adjust 't' and 'w,' monitor the 'Number of Triggers' display and make corrections to increase or decrease the number of triggers counted in a sample. The default settings have been selected to count the maximum number of valid triggers.
9. Run the VI. During each iteration, the VI samples both the trigger and frequency signals from the multiplexer until the capture buffer is full. It then,

reads from the buffer, finds the valid triggers in the trigger signal and samples the frequency signal accordingly. The mean voltage in the frequency signal is determined and the corresponding velocity computed. The number of valid triggers and mean velocity found during the iteration are displayed.

10. When the VI finishes, a mean velocity across all of the iterations is displayed. The mean velocities, from each iteration, are compiled in a histogram to evaluate confidence in the mean velocity measured.