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A Compact Direct-Detection Doppler Lidar for Wind Profiling

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1. Introduction

High spatial and temporal resolution wind measurements from ground-based or airborne remote-sensing systems are important for modeling and forecasting various atmospheric phenomena. High sensitive Doppler lidar systems with direct detection scheme have been developed for wind velocity measurement using the Mie scattering from aerosols or the Rayleigh scattering from air molecular[1-4]. These lidar systems require a high power laser and a large optical system,which limits the practical use of the Doppler lidar.

In this work, we have developed a compact direct detection Doppler lidar system. A small size LD-pumped Nd:YAG Q-switched laser has been designed and single frequency and single transverse mode oscillation was achieved. By combining the transmitter laser and a small receiving telescope, the optical system can be scanned by the control of a personal computer. The total system is expected to be transportable by a compact automobile for practical field measurements.

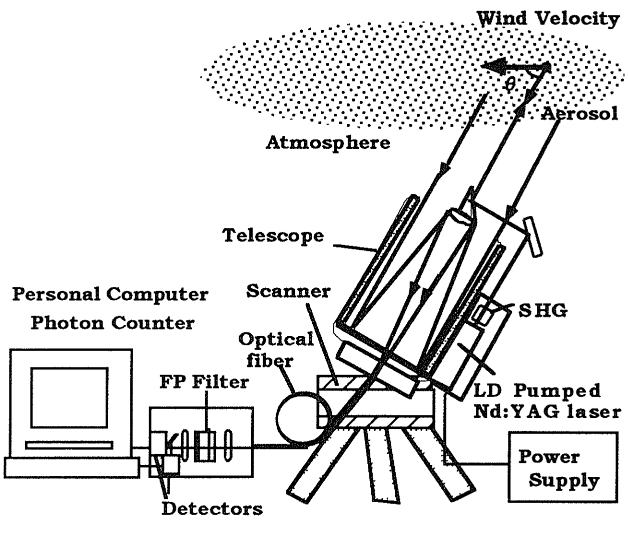

Fig. 1 Arrangement of the compact Doppler lidar system.

2. Compact Doppler lidar system

The arrangement of the Doppler lidar system is shown in Fig. 1. The transmitter is a CW-LD pumped Q-switched Nd:YAG laser with single frequency and TEM_{00} mode second harmonic output at 532 nm wavelength.[5] The laser repetition frequency is 1 kHz and the pulse energy is 0.5 mJ. Total volume of this laser head is 1/8 of our previous commercial laser of the Doppler lidar systems[4]. The backscattered light by aerosols is collected by a 20.3 cm diameter, 1.28 m focal length reflection mirror and transmitted through a 50 µm core diameter multi-mode optical fiber. The signal light is collimated and incident to the air-spaced Fabry-Perot etalon filter with the bandwidth of 75 MHz (FWHM) and the FSR of 3.0 GHz at 532 nm. The signal is detected by two photomultipliers with a photon counter system and processed by a personal computer.

Table 1 System parameters

Laser: CW-LD pumped Q-switched Nd:YAG (SHG)	
Wavelength	**532 nm**
PRF	**1 kHz**
Pulse energy	**0.5 mJ**
Receiver	
Telescope diameter	**203.2 mm**
Telescope focal length	**1280mm**
Fiber diameter	**50 mm**
Filter: Fabry-Perot Etalon	
Spectral width	**75 MHz**
FSR	**3.0 GHz**
Finesse	**40**
Max transmittance	**62 %**

For the high sensitive detection of Doppler shift of the Mie signal, a two-channel filter or a double edge filter is usually employed using two etalons. We have developed the two-channel filter with only one etalon, as shown in Fig. 2. The frequency dependence of the transmitted light on incident angle is used with a beam separation mirror. Fig. 3 is an example of the transmission functions of the 2-channel filter measured using the laser with the spectral width of nearly 180 MHz.

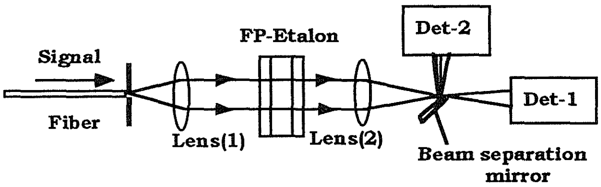

Fig. 2 Diagram of the two-channel Fabry-Perot filter.

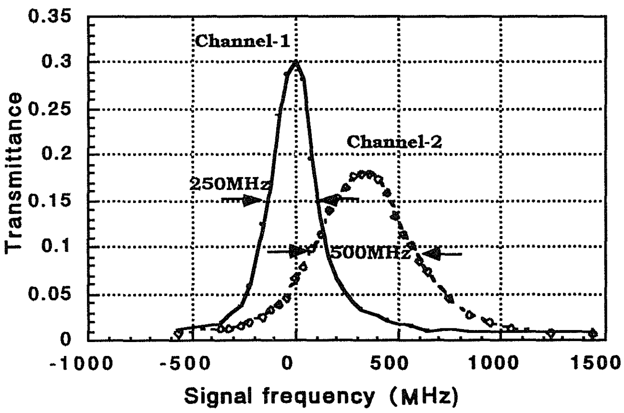

Fig. 3 Transmission functions of the 2-channel filter, observed with 180MHz spectral width laser beam.

3. Experiment results and discussion

Some basic experiments have been carried out using the compact Doppler lidar system . Fig. 4 shows an example of the wind measurement result, and two-channel signal power ratio I_1/I_2 is plotted as a function of range for 4000-shot observation. The ratio I_1/I_2 corresponds to the radial wind velocity. The standard deviation of the measured wind velocity was about 0.5m/s at 2km and 1.3m/s at 3km. Velocity calibration will be performed in the near future using standard wind sensors such as the rawinsonde.

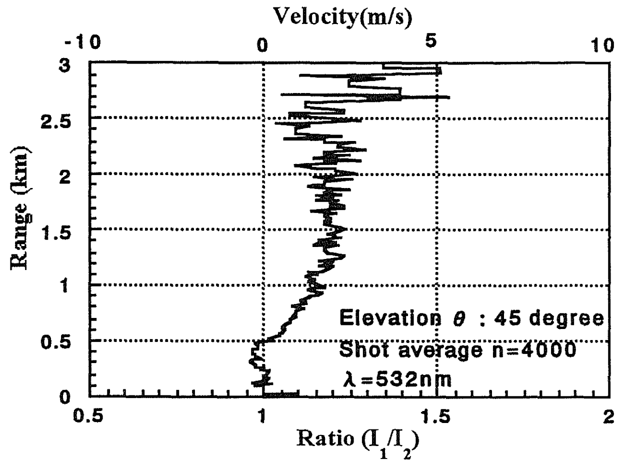

Fig. 4 Experimental result of radial wind velocity profile.

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