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A POWERFUL EYESAFE INFRARED AEROSOL LIDAR SYSTEM

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INTRODUCTION

In 1992, a mobile aerosol lidar system with a powerful laser source operating at the eyesafe wavelength of 1560 nm was completed at IFU. Further improvements followed in 1993. Extensive system testing as well as routine measurements were performed during the VAST and MAPTIP international aerosol field campaigns in 1992 and 1993. In the following we give a brief summary of the system properties and performance. A full description may be found in a recently submitted publication[1].

LIGHT SOURCE

After unsuccessful attempts with an Er:YAP laser we returned to the conventional Raman-shifting technique for the generation of the eyesafe infrared radiation. Stimulated Raman shifting in deuterium was preferred to that in methane[2-4] because of problems with thermal overload and soot formation occurring even for weak focussing (f = 1.1 m)[1,5]. This behaviour is ascribed to the good spatial mode of the Nd:YAG pump laser used (Spectra Physics GCR3). With increasing pump pulse energy (> 0.2 J) fluctuations were also observed with deuterium as the medium. Gas circulation did not substantially improve the performance.

However, highly satisfactory results were obtained for backward Raman scattering in D_2. More than 135 mJ could be achieved at 1560 nm with less than 0.65 J of incident 1064 nm radiation, with a beam profile resembling that of the pump laser. Higher pump pulse energies were found to result occasionally in hot-spot formation. The high efficiency is the consequence of the narrow pump-laser bandwidth (1 GHz) and most likely also to the well-known pulse compression of backward Raman light which leads to an emission of the pulse prior to the build-up of any thermal overload. It has to be noted that gas purity is also one of the key quantities. E.g., wall desorption of impurities with a misaligned laser beam may lead to a complete loss of Stokes output.

The finally chosen transmitter set-up is depicted in Fig. 1.

RECEIVER AND ELECTRONICS

The receiving telescope (f/5 Newtonian, 38 cm diameter, Intercon Spacetec) is attached to the bottom side of the laser table which can be tilted to more than 35°. A special wide-angle eyepiece is used to create a narrow exit pupil on the detector surface (diameter 1.7 mm). The detector itself is a InGaAs photodiode (EG&G) with 2.0 mm diameter. It replaces an initially used commercial combination of a cooled Ge diode and a preamplifier which did not meet the specifications. A custom-made preamplifier was matched to both the new detector and the 10 MHz/12 bit transient digitizer (FAST ComTec) which is reached via a triaxial cable 5 m long. The transient digitizer settings and operation are fully PC controlled.

SYSTEM PERFORMANCE

The finally obtained (peak) signal-to-noise ratio for averaging the signals for several hundred laser shots exceeds 10^4. The noise (30 μV in, e.g., the 1 V input range of the digitizer) corresponds roughly to the averaged digitization noise of the transient digitizer. This performance allowed, e.g., in a slant-path measurement, to resolve backscatter signal from thin cirrus clouds at a distance of 28 km. In this example, the noise level could be substantially reduced by chosing the 0.1 V input range of the digitizer in which, however, the near-range signal is cut off.

The only residual problem is a small interference by the pump-laser flash lamps which generates a baseline distortion of up to 0.5 mV for distances below 15 km. Further improved shielding is expected to yield the desired optimum performance.

SYSTEM SPECIFICATIONS

Transmitter:

Laser:	Nd:YAG, Raman shifted in D_2
Pump-laser bandwidth:	1 GHz
Operating wavelength:	1560 nm
Max. pulse energy:	> 135 mJ
Operating pulse energy:	115 mJ
Beam divergence:	0.6 mrad
Beam diameter (full):	10 mm
Repetition rate:	10 Hz

Receiver:

Telescope:	f/5 Newtonian, f = 2 m 38 cm diameter,
Detector:	InGaAs photodiode, 2 mm diameter
Preamplifier output pulse width:	100 ns
Transient digitizer:	10 MHz/ 12 Bit,
Averaging:	$\leq$ 500 shots

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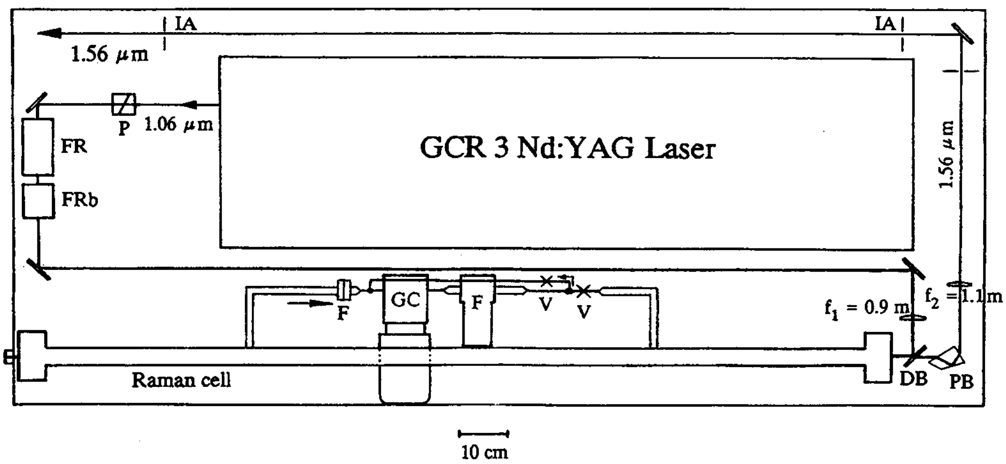

Fig. 1: Layout of the transmitter section of the eyesafe lidar; P: Glan polarizer; FR: Faraday rotator; Fb: Fresnel rhomb; PB: Pellin-Broca prism; DB: dichroic beamsplitter; IA: iris aperture; F: filter; GC: gas circulator; V: valve