STUDIES ON NOISE AND SIGNAL TO NOISE RATIO IMPROVEMENTS FOR AN IN HOUSE DEVELOPED MIE LIDAR

P Sudhakar[1], K Anitha Sheela[2] and M Satyanarayana[3,4]

[1]Department of ECE, Geethanjali College of Engineering & Technology. Cheeryal (V), Keesara (M), Hyderabad-501301
Email: pillodisudhakar@gmail.com
[2]Department of ECE, JNTUH College of Engineering Hyderabad (Autonomous), Hyderabad-500085, INDIA
Email: kanithasheela@gmail.com
[3]Ananth Technologies Ltd (ATL) Hyderabad - 500081, INDIA
[4] Department of ECE, VNR Vignan Jyothi Institute of Engineering & Technology, Hyderabad – 500090
Email:drsatyanarayana.malladi@gmail.com

ABSTRACT

A Multi-wavelength laser radar has been designed and developed in-house and made operational at the location Cheeryal Village (17.51° N, 78.62° E), which is at a distance of about 20 Km in the suburbs of Hyderabad, India. The Nd:YAG laser (M/S Bright Solutions, Italy) based multi-wavelength lidar operates at 532 nm and 1064 nm with a pulse energy of 50uJ at both the wavelengths. The two wavelengths are generated coaxially with a pulse width of 10ns and the laser operates up to a PRF of 4 KHz. The receiver system consists of a 360 mm Newtonian optical telescope, 10 nm of interference filters and the Licel Gmbh, Germany make 250 MHz Photon Counting recorder. In this paper we present the different sources of noise and their probability density functions and noise estimations. The signal to noise ratio improvements are carried out on the data to the in house developed lidar system such as threshold, coherent and incoherent averaging.

Keywords:

Lidar, Remote sensing, noise, signal to noise ratio, averaging

1. Introduction

Lidar is an acronym for light detection and ranging. Lidar systems are laser based systems that operate on principles like that of radar (radio detection and ranging). In the case of lidar, a light pulse is emitted into the atmosphere. Light from the beam is scattered in all directions from molecules and particulates in the atmosphere. A portion of the light is scattered back toward the lidar system. This light is collected by a telescope and focused upon a photo detector that measures the amount of back scattered light as a function of distance from the lidar. The interaction of the emitted laser beam with the atmospheric constituents causes alterations in the intensity, polarization and wavelength of the backscattering light. From the measurement of these parameters of the received backscattered light one can deduce the properties of the atmosphere and its constituents. As the laser is pulsed the lidar methods allows the range resolved measurement to obtain the vertical profile of the parameter being studied. Lidar systems are used in the wavelength range extending from the Ultra Violet to the Infra-Red (UV to IR) by using different types of lasers. Elastic lidars, in which the transmitted and scattered back signals are at same wavelengths, aims to detect Rayleigh and Mie scattering from atmospheric gas molecules and aerosols respectively. These types of scattering are characterized from the detection of a photon by a gas molecule or dust particle in an elastic collision, meaning that the energy of the photon is conserved. It can map aerosol concentration in the atmosphere and to determine aerosol particle size (M. Hess, P. Koepke, and I. Schult, 1998) [1]. This makes lidar an enormously useful tool for investigating air-quality, both generally and in the context of agricultural operations in particular. In fact, the use of lidar to map particulate matter (PM) concentration and estimate aerosol emission rates from an agricultural facility has been demonstrated previously, and lidar has been proven to be a versatile tool for investigating atmospheric aerosols and a useful means of characterizing and monitoring the air-quality impact of industrial and agricultural operations (M. D. Guasta, et.al, 1994) [2]. The field of laser remote sensing has grown rapidly in recent years. The growth has been stimulated by the potential application of remote sensing systems to a wide variety of atmospheric measurements.

2. System description

The Lidar system has been designed developed and operationalised for regular scientific studies on aerosols and clouds in the atmosphere. The Schematic diagram of the Lidar system developed is shown below in Figure 1 (a). Figure 1 (b) shows the lidar system developed. Brief specifications of the system developed are outlined in

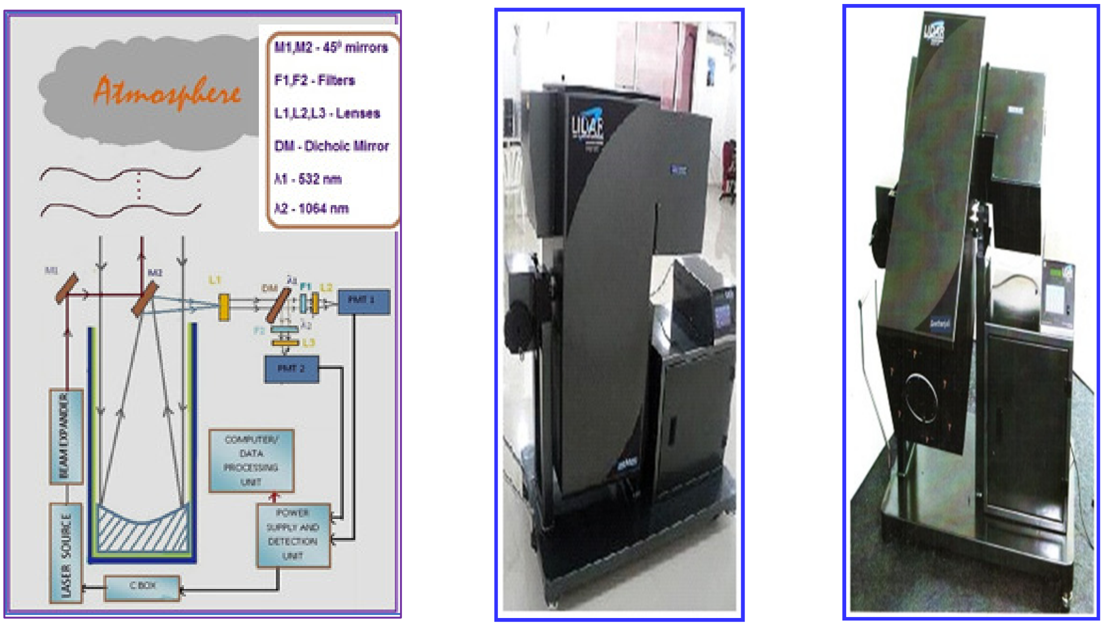

Figure 1 The Schematic diagram and the lidar system developed

3. Noise and SNR improvements in mie lidar

A challenge of Atmospheric Radars and Lidars is that they require large amount of data to be collected as the atmospheric phenomena have large time constants. The signals have large dynamic range of the order 10-12 decades. The signals are buried in noise. The SNR changes from low values to High value typically from -30dB to + 10 dB, and in many occasions it is less than '0' dB. Lidars encounters two types' noises. The Optical noise which follows Poisson distribution, which the signal dependent. The second is the electronic noise follows the Gaussian distribution and is signal independent. The noise is handled by the processes of threshold, coherent averaging and incoherent averaging. The coherent averaging technique, in which pulse to pulse averaging is done, improves SNR by 10logN, where N is the number of pulses averaged. On the other hand, the incoherent averaging technique, in which range bin to range bin averaging is done, improves SNR by 10log√m. Here m is the number of range bins .The uncertainty level in the photon counts measurement is shown in the fig.2. The probability of error with respect to the photon counts is shown in fig. 3. The SNR is estimated from the measured data. Fig 4 shows SNR with respect to range. Various types of noises are also shown in this figure

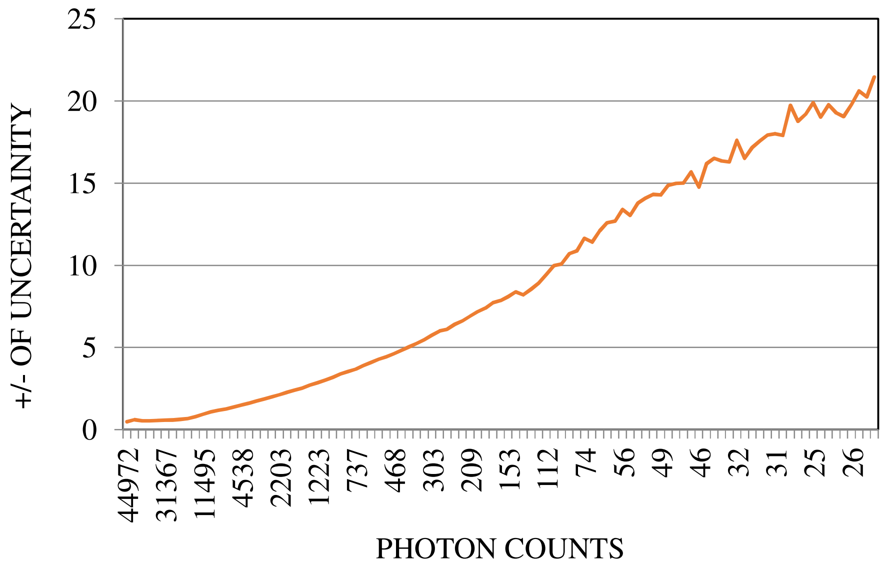

Fig. 2. Uncertainties in photon counts measured

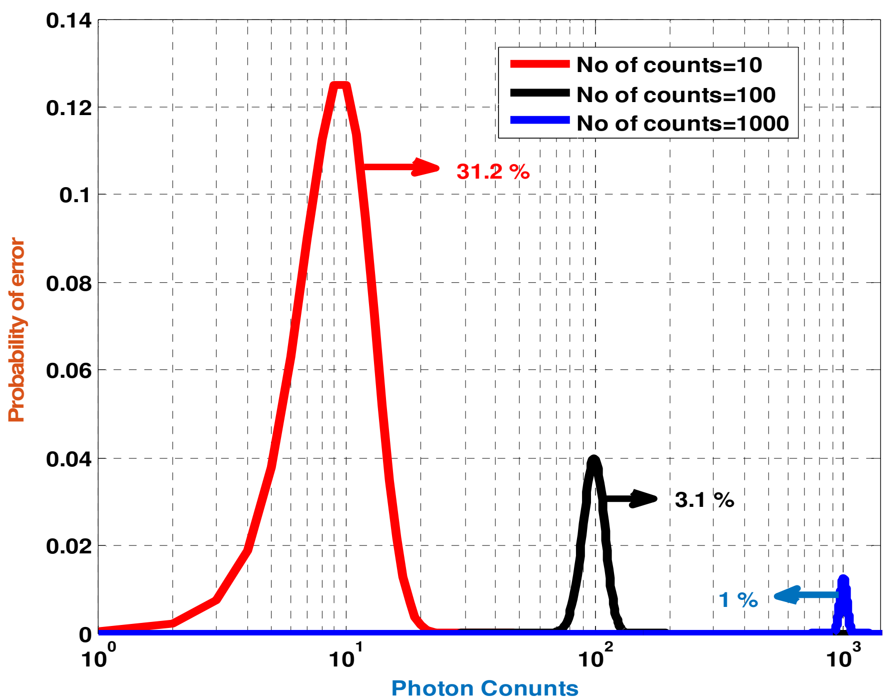

Fig. 3 Photon counts vs Probability of error

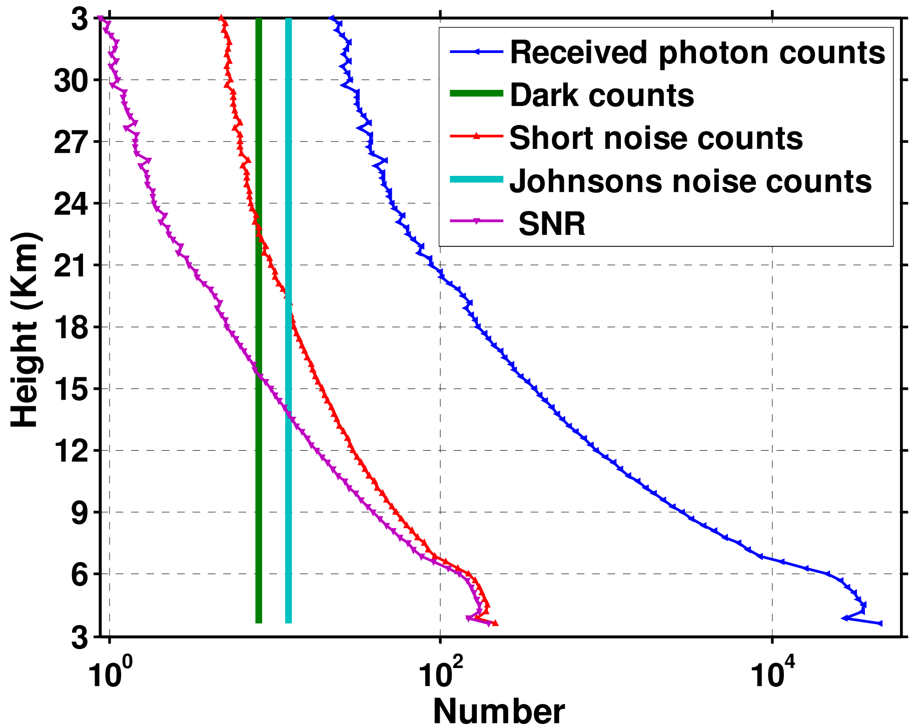

Fig 4 Estimation of SNR from the measured data

4. Conclusions

An inhouse developed mie lidar system for measurement of aerosols is presented. Various sources of noises, noise estimation and SNR improvement methods have described briefly.

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