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Atmospheric Monitoring with LIDAR method for the TA Experiment

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We have been studied to measure the atmospheric transparency by the method known as LIDAR. The prototype was developed at AKENO observatory and it had the performance to measure approximately distance exceeding 10km. A new prototype LIDAR system for the Telescope Array (TA) experiment has been developing at Kinki University and first prototype was installed at Black Rock Mesa in Utah, USA. The aim of LIDAR is to determine the atmospheric extinction length within 20 km accurately in desert circumstances based on the result of AKENO experiences. We shall report present status of atmospheric monitoring system and our future plan in brief.

1. Introduction

Atmospheric monitoring plays very important roles for cosmic ray experiment using air fluorescence detection experiment technique because propagation of fluorescence light is depend on atmospheric condition between its origin and detector. Our aim of measuring atmospheric transparency is to correct detection atmospheric fluorescence light induced by EAS which corresponds to primary cosmic ray energy. We have been developed atmospheric monitoring system which is called LIDAR(LIght Detection And Ranging). Basic conceptual design of atmospheric monitoring with LIDAR system has been studied at Akeno Observatory in Japan commencing from 1997. This LIDAR observes back scattered light of laser by air molecules (Rayleigh scattering) and by aerosol (Mie scattering) in the atmosphere. The system is composed of a Nd:YAG laser, a light collecting telescope, a PMT, and a digital oscilloscope. The aim of LIDAR is to measure atmospheric transparency within the range of 20km in Utah desert. The first LIDAR system was installed in an astrodome at Black Rock Mesa in Utah where is the first location of TA and prepare to measure atmospheric transparency.
Atmospheric extinction length is determined by solving the Klett's method of LIDAR equation to the observed data. We adopt the Klett's method due to it gives very reasonable solution for the extinction length even including boundary condition problem.

2. Experimental equipments

A Our new LIDAR system is composed of a Nd:YAG laser, a scattering light collection mirror, a digital oscilloscope, and a computer as shown in Figure 1. Some specification of each component is also shown in Tabl-1. The laser is mounted on alt-azimuth steerable telescope and is controlled by PC through network. A wave length of the laser is 355nm (third harmonic wave) and having maximum power of 5mJ at 20Hz repetition rate. A sample data of Laser energy is shown in Figure 2. It achieves spatial resolution of approximately a few ten meters due to its pulse width of 5ns and 11 bit ADC resolution of digital

oscilloscope. A light collection efficiency of a 30 cm telescope mirror has about 80% for UV wavelength. The collecting light is focused on the surface of 3/4" PMT and light is magnified 10^6.

Table 1. Specification of LIDAR system

Nd:YAG laser	355nm, 5 mJ 5ns pulse laser
mirror	30cmφ in diameter
PMT	3/4" Gain ～10^6
ADC	FADC 11bit spatial resolution : few 10m
FOV	approx. 1 degree

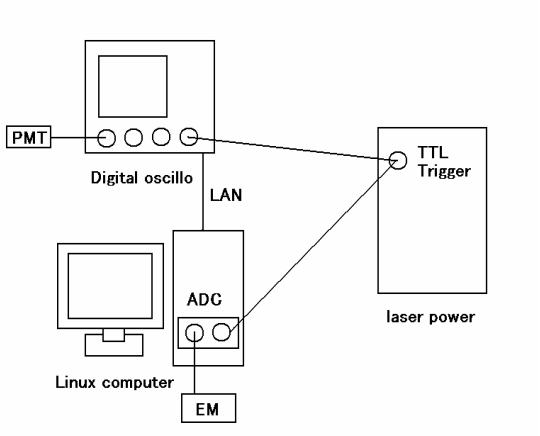

Figure 1. Block diagram of the LIDAR system

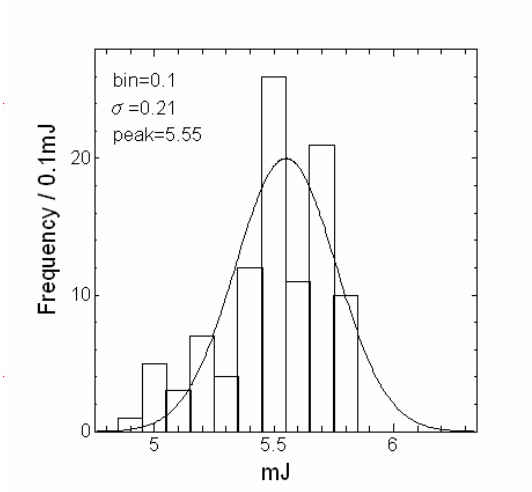

Figure 2. A sample of Laser energy

Figure 3. The LIDAR system installed at Black Rock Mesa

3. Installation of LIDAR system into Black Rock Mesa

We construct an astrodome in November 2004 at Black Rock Mesa in Utah and installed the LIDAR hardware into the astrodome in Mar 2005. Now we try to make and adjust the complete system to measure atmospheric condition. The astrodome is located about 100m from main building of fluorescence detectors. DAQ data will be sent by wireless LAN connecting between the astrodome and main building. And the LIDAR system will be controlled through network from Japan in future. Fig-3 shows the LIDAR system in the astrodome. The mirror, laser, and optics is settled on a steel post and height of the centre of laser beam is about 230cm from ground. DAQ electronics including PC are also settled in the dome.

4. Cloud monitoring with CCD camera

We also monitor the cloud condition so that the cloud region effects observing fluorescence light from cosmic ray to the fluorescence detectors. The cloud monitoring system consists of a well PC controlled CCD image sensor which observe cloud in the night. FOV of the CCD camera is approx. hundred degrees in horizontal and vertical direction using an fish eye lens. A sensitivity of CCD is less than 0.001Lux.

Figure 4. The CCD cloud monitoring system installed at Black Rock Mesa

5. Prospects

A hardware of the first LIDAR system has been installed at the first TA FD location, Black Rock Mesa. FD detectors are under construction now and their first test run will be held at the beginning of July. At that time, the LIDAR will be used as steerable light source in order to check the FD electronics. In the TA experiment, three more steerable LIDAR system and a fixed vertical laser system will be deployed to monitor the whole region of the cosmic ray observed volume with less than 10% accuracy of the extinction length for atmosphere.

6. Acknowledgements

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