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Ashra Mauna Loa Observatory and Slow Control System

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Abstract: The observation site of Ashra (All-sky Survey High Resolution Air-shower detector) is located on Mauna Loa in Hawaii. A part of the Ashra detectors have already been constructed, and pilot runs of optical GRB observation and atmospheric Cherenkov light detection have been operated using them. Slow control system including Cloud Monitor have also been tested during the pilot runs. We report the current status of the Ashra Mauna Loa Obaservatory.

Ashra

Ashra is a new experiment which has an ability to detect air fluorescence light and atmospheric Cherenkov light yielded by high-energy cosmic rays[1]. In addition to cosmic ray detection, it is able to observe stars and transient objects optically. As the name shows, Ashra covers 80 % of the sky (80 % of 2π [str]) with light collectors of $42°$ field of view (FOV) and of a few arcmin optical resolution[2].

Air-shower events and star images in the FOV are obtained using Image Pipeline which consists of 20 inch electro-static image intensifier (I.I.), proximity I.I.s, trigger sensors and an imaging CMOS sensor[3].

The major gain from such very wide FOV detector is the ability to monitor the almost whole sky continuously for an extended period, making an unprecedented search for new point sources such as gamma-ray bursts (GRBs), supernovae and unidentified sources of other energy ranges.

Ashra Mauna Loa Observatory

Ashra Mauna Loa Observatory, the observation site of Ashra phase 1, is located at an elevation of 3,300 m of Mauna Loa on the Island of Hawaii (N$19.54°$, W$155.57°$). Mauna Kea can be viewed on the north side about 35 km far from Mauna Loa and it can be used as a huge target mass for earth skimming tau neutrinos.

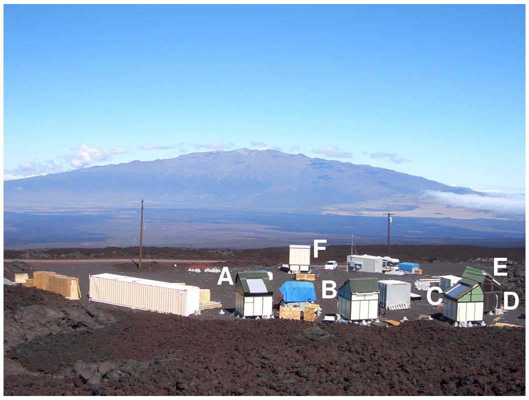

Figure 1: Ashra Mauna Loa Observatory in Dec 2006. The mountain in the center of the picture is Mauna Kea. A∼E are light collectors which monitor around the zenith of 30°. F monitors tau neutrinos coming through Mauna Kea.

We have been conducting construction of light collectors and pilot observations since September 2005. Fig. 1 shows the current (December 2006) view of the site. 6 of 28 light collectors have already been constructed by the end of 2006. The Optical System and Image Pipeline have been installed in part of them. Construction of light collectors totaling 28 is scheduled to be finished in summer of 2007.

Pilot Runs

Using part of completed light collectors, pilot runs of atmospheric Cherenkov light detection and optical GRB observation were conducted between May 2006 and March 2007 following the earliest test on Haleakala, Maui[4].

One of the unique features of Ashra is that it has three different time scales: ~ 100 [ns] for Cherenkov light, $\sim 10-100$ [μs] for fluorescence light and ~ 10 [s] for star light[5][4]. These three modes work simultaneously with only one Image Pipeline. Same image is split to three different sensors using half mirrors and optical fibers.

Event images of these three modes are obtained with the resolution of a few arcmin. This resolution and wide FOV are achieved by modified Baker-Nunn optics which consists of three acrylic lenses and seven segment mirrors. The photocathode of 20” I.I.s work as a focal plane. Fig. 2 is a ray trace of the optics.

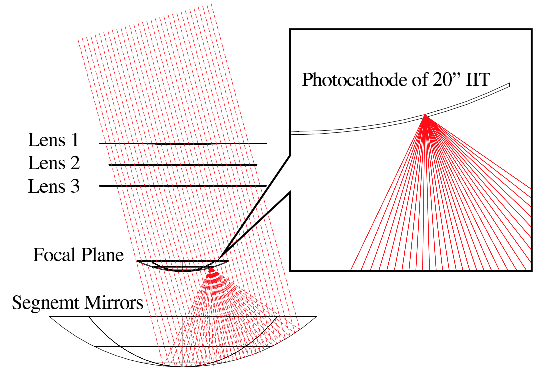

Figure 2: Ray trace of the Optics of Ashra.

In spite of its resolution and FOV, alignment of optical components (segment mirrors, acrylic lenses and focal plane) is simpler than other cosmic ray detectors or astronomer’s telescopes. Because it does not need any online adjustment nor active actuators. It always views a fixed area. Thus the order of alignment accuracy is sub-millimeter that can be adjusted by hand. This is very important to reduce the cost of construction of a few tens of light collectors.

Fig. 3 shows an image example of untriggered mode during the pilot runs. We achieved a few arcmin resolution in the FOV.

We confirmed that the optics could be well aligned, data flow worked smoothly. Data acquisition of un-triggered images was conducted in two months without any major problems. Unfortunately, no GRB has occurred in our FOV during the observations. However time zero of GRBs will be observed by Ashra after the start of official run in September 2007.

Slow Control System

We also operated our slow control system during the pilot runs. It includes Cloud Monitor, Weather Monitor, power control, tempera-

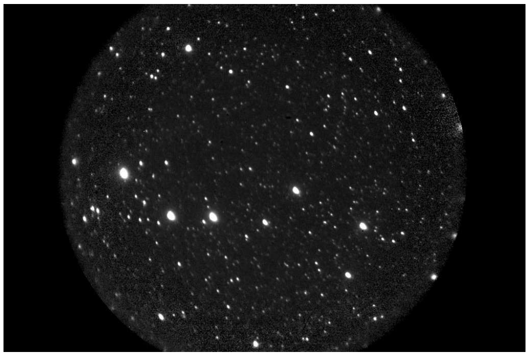

Figure 3: Sky image in the area within the radius of $21°$ from the point of $(\mathrm{zenith} = 30°, \mathrm{azimuth} = 0°)$. The exposure time is 4 [s]. The seven bright stars are the Big Dipper. Note that saturated stars are not good indicators of resolution.

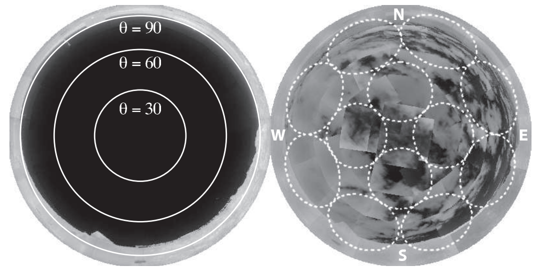

Figure 4: Near-infrared cloud images. Left: Clear sky. Right: Cloudy sky. The center of each image is the point of $\mathrm{zenith} = 0°$. The area of $0 \leq \mathrm{zenith} \leq 100°$ and $0 \leq \mathrm{azimuth} \leq 360°$ is drawn in one image. Each solid line shows zenith of $30°$, $60°$ and $90°$ respectively. Dashed lines are FOVs of light collectors. Top is the north side and left is the west side.

ture/humidity control and so on. We focus on Cloud Monitor in this section.

Operators have to be careful of the weather conditions during observations in cosmic ray experiments. Because optical thickness of the atmosphere depends on the quantity of clouds, and operations should be shut down before it rains. Humidity can be an indicator of rain but it is not enough for a rain shower forecast on the mountain. The simplest way to know signs of rain is to grasp conditions of clouds. However clouds are not visible to human eyes on moon-less nights.

We have developed Cloud Monitor which visualizes near-infrared radiation from clouds. There have already been some cloud monitors utilizing near-infrared (for example [6]). However we need original system which has wider FOV and better cost performance. Because the FOV of Ashra covers even beneath the horizon.

We used mainly two products: IR-U300M1 (Mitsubishi Electronics) and ETX-90/EC (MEADE). The former is a CCD camera which is sensitive to near-infrared, and the latter is an altazimuth telescope for amateur astronomers. The telescope is used as just a camera platform. Since the camera has only $29° \times 21°$ FOV, composite images are created from 54 images of different directions. Control of the instruments is executed from a Linux PC through RS232C, and each image is stored in FITS format. Fig. 4 shows image examples of Cloud Monitor.

Weather Monitor is also equipped at the site to measure temperature, humidity, wind speed and atmospheric pressure. It monitors external conditions of the light collectors. Collaborating with Cloud Monitor, it helps operators to decide to start/stop observations.

Since day-by-day variation of internal conditions of light collectors may cause degradation of optical system, internal temperature and humidity are also being monitored by small chip sensors SHT71 (Sensirion).

Summary

The status of Ashra is changing from the developmental phase to observation phase. Most parts of the detector system are ready and have been tested in pilot runs. After completing construction of light collectors, untriggered observation and search for transient objects are scheduled to be started from September 2007, and TeV γ-ray observation will follow it.

Acknowledgments

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