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The Telescope Array Experiment: Status and Prospects

H Tokuno[1], R U Abbasi[2], T Abu-Zayyad[2], R Azuma[3], J W Belz[2], T Benno[4], D R Bergman[5], S A Blake[2], O Brusova[2], R Cady[2], Z Cao[2], B G Cheon[6], J Chiba[7], M Chikawa[4], I S Cho[8], T Chung[9], F Cohen[1], K Doura[4], T Doyle[10], A Endo[11], H Fujii[12], T Fukuda[3], M Fukushima[1], Y Hayashi[13], K Hayashi[13], N Hayashida[1], K Hibino[14], K Hiyama[1], K Honda[15], P Huentemeyer[16], G A Hughes[5], T Iguchi[3], D Ikeda[1], K Ikuta[15], N Inoue[11], T Ishii[15], C C H Jui[2], K Kadota[17], F Kakimoto[3], T Kanbe[15], K Kasahara[18], H Kawai[19], S Kawakami[13], S Kawana[11], E Kido[1], Y Kondo[1], Y J Kwon[8], S Machida[3], K Martens[2], T Matsuda[12], T Matsuyama[13], J A J Matthews[20], J N Matthews[2], M Minamino[13], K Miyata[7], M Mostafa[2], Y Murano[3], T Nakamura[21], S Nam[9], T Nonaka[1], S Ogio[13], S Oh[9], M Ohnishi[1], H Ohoka[1], A Ohshima[13], T Okuda[13], J Ormes[22], S Ozawa[1], I H Park[9], J H Park[9], D Rodriguez[2], H Sagawa[1], N Sakurai[1], L M Scott[5], T Shibata[1], N Shimizu[13], H Shimodaira[1], G Sinnis[16], J D Smith[2], P Sokolsky[2], R W Springer[2], S R Stratton[5], S Suzuki[12], M Takeda[1], A Taketa[1], M Takita[1], Y Tameda[3], K Tanaka[23], M Tanaka[12], H Tanaka[13], M J Taylor[10], M Teshima[24], J R Thomas[2], S B Thomas[2], G B Thomson[5], T Tomida[15], R Torii[1], Y Tsunesada[3], Y Uchihori[25], S Udo[1], Y Unno[6], Y Wada[11], V B Wickwar[10], L R Wiencke[2], T D Wilkerson[10], Y Yamakawa[1], H Yamaoka[12], J Yang[9], S Yoshida[19], H Yoshii[26], and Y H Yun[6]

[1] Institute for Cosmic Ray Research, University of Tokyo, Kashiwa, Japan
[2] University of Utah, Salt Lake City, USA
[3] Tokyo Institute of Technology, Tokyo, Japan
[4] Kinki University, Osaka, Japan
[5] Rutgers University, Piscataway, USA
[6] Hanyang University, Seoul, Korea
[7] Tokyo University of Science, Noda, Japan
[8] Yonsei University, Seoul, Korea
[9] Ewha Womans University, Seoul, Korea
[10] Utah State University, Logan, USA
[11] Saitama University, Saitama, Japan
[12] Institute of Particle and Nuclear Studies, KEK, Tsukuba, Japan
[13] Osaka City University, Osaka, Japan
[14] Kanagawa University, Yokohama, Japan
[15] Yamanashi University, Kofu, Japan
[16] Los Alamos National Laboratory, Los Alamos, USA
[17] Musashi Institute of Technology, Tokyo, Japan
[18] Pusan National University/ARCSEC, Pusan, Korea
[19] Advanced Research Institue for Science and Engineering, Waseda University, Tokyo, Japan

[20] Chiba University, Chiba, Japan
[21] University of New Mexico, Albuquerque, USA
[22] Kochi University, Kochi, Japan
[23] University of Denver, Denver, USA
[24] Chungnam National University, Daejeon, Korea
[25] Hiroshinma City University, Hiroshima, Japan
[26] Max-Planck-Institute for Physics, Muenchen, Germany
[27] National Institute of Radiological Sciences, Chiba, Japan
[28] Ehime University, Matsuyama, Japan

E-mail: htokuno@icrr.u-tokyo.ac.jp

Abstract. Telescope Array (TA) is a hybrid detector of a surface detector array and fluorescence telescopes. This hybrid detector will measure the energy spectrum, anisotropy and composition of ultra-high energy cosmic rays (UHECRs) to identify their origin. The almost construction of the detector has been completed in May 2007, and the detector is running under test and adjustments. The first hybrid observation with the full configuration is planned in beginning of 2008. In this paper the status and prospects of TA detector is described.

1. Introduction

Ultra high energy cosmic rays (UHECRs) will interact with the cosmic microwave background. Therefore a cutoff in their energy spectrum (GZK cutoff) is expected at the energy $10^{19.5}$ eV by Greisen, Zatsepin and Kuzmin [1]. However, the AGASA result shows that there are 11 events beyond the GZK cutoff [2]. In contrast, HiRes group reported that there is a GZK cut-off in their observed energy spectrum [3]. AGASA and HiRes claims their uncertainty in energy determination is 18% and 17% respectively. The rescaling spectra of AGASA and HiRes within their uncertainties in agree well below 10^{20} eV. It seems that the inconsistency is due to the systematic uncertainties of both experiments in energy determination. In order to make clear the difference, and to get definite answer on the origin of UHECRs, we will observe extensive air showers (EASs) with a hybrid detector which consists of an AGASA type surface detector (SD) array and with HiRes type air fluorescence detectors (FD) simultaneously. Using the hybrid detector the difference of the energy spectrum observed by AGASA and HiRes can be studied on event by event above 10^{19} eV. The detection area of SD array is of about 700 km^2, which is 8 times larger than AGASA detection area. A sufficient statistics gives us a fine structure of the energy spectrum at GZK cutoff region, and it allows to study the distribution and property of UHECRs sources.

2. Status and Prospects

The configuration of TA detector is shown in Fig.1. It consists of a Surface detector (SD) array and three stations of air Fluorescence Detectors (FDs) surrounding SD array. This hybrid detector is located in Utah, USA (39.3° N, 112.9° W) with an average altitude of 1400 m.

The SD array consists of 512 SDs in a grid with 1.2 km spacing covering the ground area of $\sim$ 700 km^2. From our simulation studies, the trigger efficiency is expected to be $\sim$ 100 % for cosmic rays with the primary energy more than 10^{19} eV. Each SD has 2 layers plastic scintillator (thickness: 1.2 cm, area: 3 m^2). These layers are separated optically, and PMT at each layer collects signals with wavelength shifting fibers. In order to reduce trigger frequency, local electronics find a coincidence signal between upper and lower scintillator. Waveforms of PMT output recorded by local electronics are transmitted to a central DAQ system via wireless LAN. The 95 % of installation have been completed. We are adjusting equipments, and checking performances of the array. Remaining surface detectors ($\sim$20) will be installed soon, and full operation of SD array will be planed from December 2007. For more detail see[4].

Three air Fluorescence Detector (FD) stations are surrounding the SD array, and the separation of each station is ~ 30 km (Fig.1). The FD consists of spherical mirror optics, PMT camera and recording electronics system. The spherical mirror with a diameter of 3.3m consists of 18 segment mirrors whose curvature radius is 6m. The PMT camera has 256 PMTs of 16×16 matrix, and FOV (field of view) of each PMT is $\sim 1°$. The FOV of one telescope is $18° \times 15.6°$, and the total FOV for one station is $3° - 33°$ in elevation and 108° in azimuth. The waveforms of PMT are digitized by Electronics with 10MHz, 12 bit resolution and 14 bit dynamic range, and stored on HDDs. Dead time of sampling sequence is 1% at the normal trigger rate ~ 1 Hz.

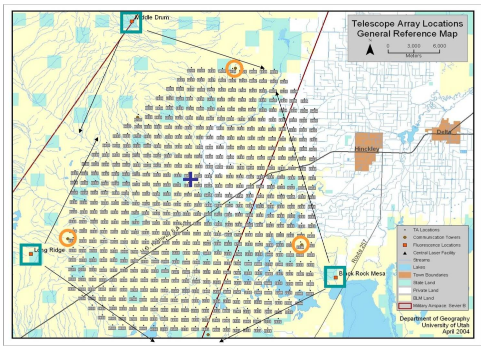

Figure 1. Detector configuration of TA. The locations of SDs are indicated by small numbers. The locations of 3 FD stations are marked by square.

From our simulation studies, trigger efficiencies of stereo events are expected to be ~ 100 % for cosmic rays with the primary energy more than 10^{19} eV. HiRes-I have been moved to the third station located on North in Fig.1. The configuration of FOV is different from HiRes-I, however, optics and electronics is same as HiRes-I. To calibrate FDs optics and monitor for transparency of the atmosphere various calibration methods will be applied[5]. For End to End calibration which includes air fluorescence yield to electronics performances, 40 MeV electron beam system will be installed on the front of the Southeast station[5]. The installation of telescopes for the first and second station have been completed and we are starting observation with stereo mode in June 2007. More details are found in[5].

SD with full operation will be started on the beginning 2008 as originally scheduled, and we should obtain the AGASA equivalent exposure by SD before TAUP 2009. At that time we will have more than 800 events with the energy $> 10^{19}$ eV, and more than 10 events with the energy $> 10^{20}$ eV with assuming the AGASA flux. The systematic uncertainties and differences of SD, FD, and Hybrid method will be understood from event by event analysis at 10^{19} eV. We will conclude the energy spectrum at the GZK cutoff region based on the results. Also we have a plan to extend to low Energy region below 10^{19} eV. It consists of infill SD array, FDs with higher altitude of FOV, and additional FDs covered the region of infill SD array (TALE experiment)[6].

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