Akeno 20km^2 Air Shower Array (Akeno Branch)

M.Teshima*, H.Ohoka, Y.Matsubara*, T.Hara, Y.Hatano, N.Hayashida, C.X.He**, M.Honda, F.Ishikawa, K.Kamata, T.Kifune, M.Mori*, M.Nagano, K.Nishijima***, Y.Ohno and G.Tanahashi

Institute for Cosmic Ray Research, University of Tokyo, Tokyo, 188 Japan
*Department of Physics, Kyoto University, Kyoto, 606 Japan
**Institute of High Energy Physics, Academia Sinica, Beijing, China
***The Graduate School of Science and Technology,Kobe University,Kobe,657

As the first stage of the future huge array we have expanded the Akeno air shower array to about 20km^2 by adding 19 scintillation detectors of 2.25m^2 area outside the present 1km^2 Akeno array with a new data collection system. These detectors are spaced about 1km from each other and connected by two optical fiber cables. This array has been in partial operation from 8th, Sep. 1984 and full operation from 20th, Dec. 1984. 20m^2 muon stations are planned to be set with 2km separation and one of them is now under construction.

1. Introduction

The origin of the highest energy cosmic rays is an interesting problem. We have a chance to connect their sources with the astronomical objects, because their propagation becomes simpler than that of lower energies and the possible sources may be limited to some kinds of active astronomical objects. The observation of giant air shower (GAS) produced by cosmic rays above 10^{19} eV have been made at Volcano Ranch[1], Haverah Park[2], Narabrai[3] and Yakutsuk[4]. But there still remain the discrepancies among experiments not only in their energy spectrum but also in their arrival direction distribution.

In order to clarify the present ambiguities on the experiments and to extend the observation to higher energy, a plan of huge surface array of area over 100km^2 is currently under discussion in Japan. In this report we describe about the "Akeno Branch" which is just constructed at Akeno with the intention of being a part of the huge array.

2. Array of "Akeno Branch"

The detector arrangement of the "Akeno Branch" is shown in fig.1. The open circles are the scintillation detectors of 2.25m^2 each, located at about 1km separation. The closed circles are scintillation counters of 1m^2 area of the

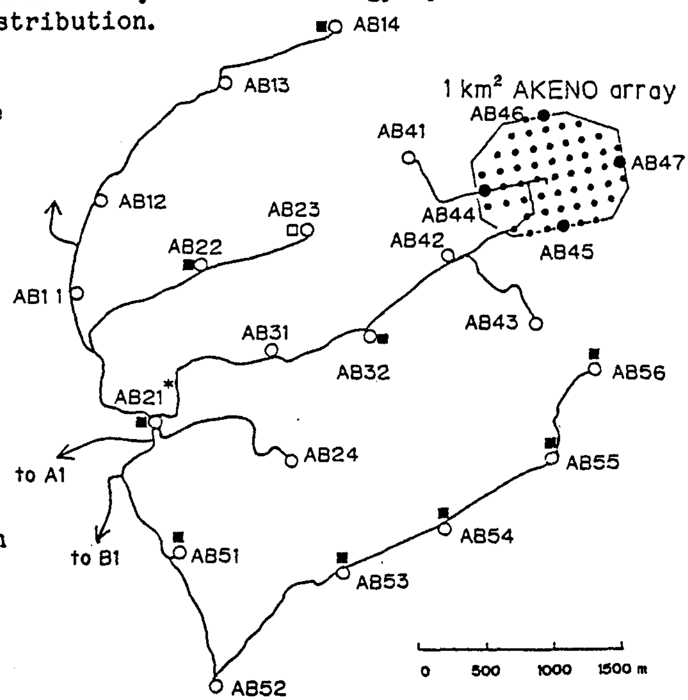


Fig.1 The detector arrangement of the "Akeno Branch".

existing "1km^2 Akeno array"[5]. The four large ones are also connected to the present new recording system. The open square is a muon detectors of 20m^2 area under construction and the closed ones will be arranged within a few years. Each detector is connected to the next one with two optical fiber cables successively on a string as shown by a solid line. One cable is used for sending the control commands to each module of the detector from the center, and the other is for data transmission.

Inside the 1km^2 array, there are unshielded detectors of total area of 169m^2, shielded detectors of 225m^2 (1GeV for vertical traversing muons) and 75m^2 (0.5GeV), and 53 fast timing channels of 10nsec resolution. These are effective to measure the properties of the large showers at far from the core.

3. Data acquisition system

In each station there is a module called Detector Control Unit (DCU) which is designed with one board micro computer(Z-80A). DCU consists of 3 major parts; communication part, data processing part and detector monitor and control part. Several DCU's are tied to a common string which consists of two directional optical fibers. One fiber of outgoing direction from the center is used to send commands, clock pulses for the timer of DCU and timer frame (clear pulse for the timer). Another one is used to accept the status information of each detector for the trigger conditions and to collect shower data and monitor data from DCU's at the center. The communication data rates on strings are 625kb/s.

Every DCU has a timer which synchronizes to that of the center with 20nsec accuracy. All signals from the detector are digitized and stored in the ring-image-memory of DCU with the incident time of 20nsec accuracy. Each DCU sends the information to the center in every 3.2 μsec period whether the detector is hit by a particle or not. With this status information, coincidence requirements can be set at the center. 6 folds coincidence of neighbouring detectors is required for the trigger. When GAS hits over the array, central unit recognizes coincidence of signals from many detectors and knows its occurence time. Then the central unit issues a command for all DCU's to search for the GAS data in the ring memory with the time information of coincidence. Each DCU which has accepted this command, stops data acquisition and searches for the all corresponding data recorded within 100 μsec before and after the coincidence. Central unit commands DCU's to send the picked out data one by one. These data are sent to micro-computer(NEC 16bit PC9801) at Akeno central laboratory through RS232C line of optical fiber and stored in the 10MB Hard Disk.

With this system not only the air shower data and monitor data are acquired but also detector conditions can be controlled at the center. Supplied voltage to the phototube, temperature, counting rate and pulse height distribution of detectors are monitored periodically. The discrimination level of the amplifier and the high voltage to the phototube can be controlled on request from the center. These functions enable us to maintain the detectors stable for long term and make data reliable. The details of this system are described in Ohoka and Teshima[6].

4. Array response

The response of the present array was examined by analyzing the artificial showers which were simulated by the Monte Carlo method. The fluctuations of electron density and the shower front structure at core distances between 500m and 3000m of 10^{18}-10^{19}eV EAS observed at $4km^2$/$20km^2$ array[7] were used for the present simulation.

The threshold energy of detectable air shower is found to be about $10^{17.5}$eV and the recording efficiency reaches 100% at $10^{18.5}$eV as shown in fig.2. The histograms show the response and effective area for the showers hit inside the array. The broken line shows the area for all events including outside the array. The sensitivity for shower size and arrival direction in case of showers hit inside the array are shown in fig.3(a),(b) respectively. We can determine the electron size with 30% accuracy, arrival direction with 3 degree and core position with 80m. However for the showers outside the array, these are 150%, 9 degree and 150m, we need much caution to use the outer showers for the discussion of primary energy spectrum and their arrival directions.

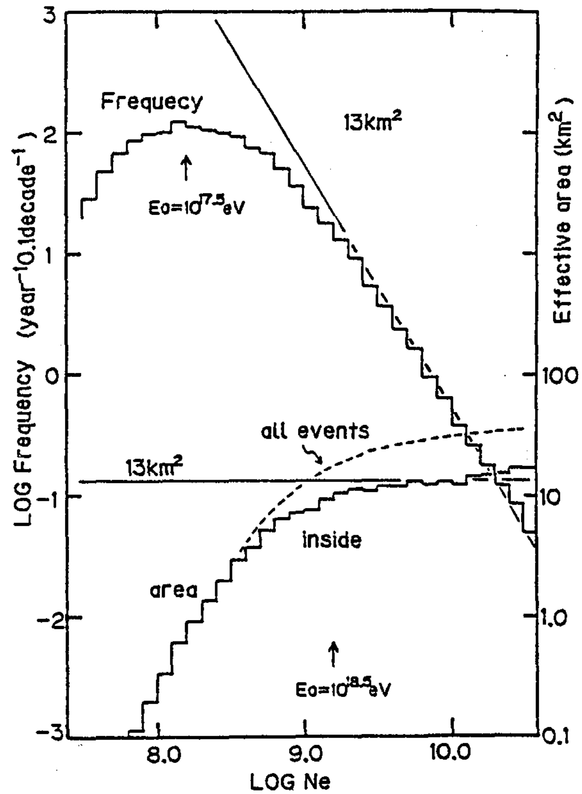
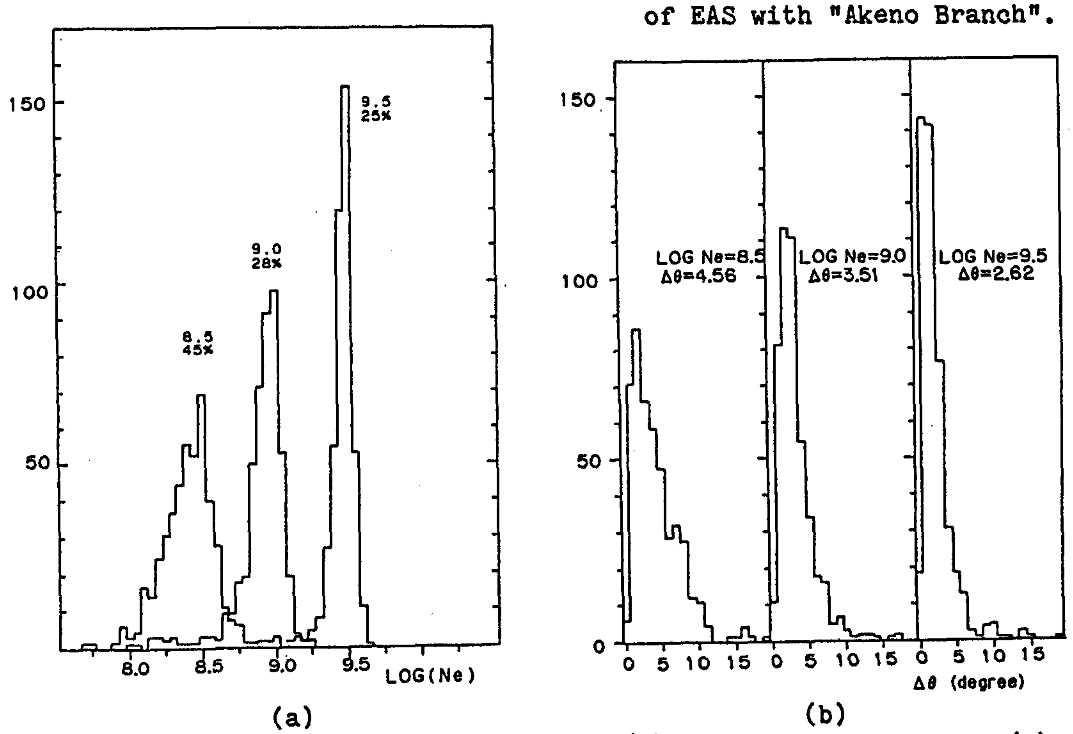


Fig.2 The detection efficiency of EAS with "Akeno Branch".



(a) (b)

Fig.3 The sensitivity for shower size(a) and arrival direction(b) in the case of showers whose core hit inside of array.

5. Conclusion and future plan

The observation of ultra high energy cosmic rays has started at Akeno. In order to determine their origin, the expansion of array to 100km^2 is under planning. The technical problems for expansion is already solved through the experience under the construction of Akeno Branch.

The schematic diagram of recording system of the future array is shown in fig.4. The whole array is divided into several Branches. Each Branch is managed by BCU(Branch Control Unit) which is connected successively to the next one with two optical fiber cables "String". This structure is exactly the same as that inside Branch. The commands from the center and data from the Branch are put on this "String". The clock pulse is supplied from the central unit SCU(System Control Unit) to each DCU(Detector Control Unit) via BCU (Branch Control Unit). Since the timer of every DCU synchronizes to the central timer, we can manage the GAS hit in the boundary gap between branches, in the same way as ones hit inside a Branch.

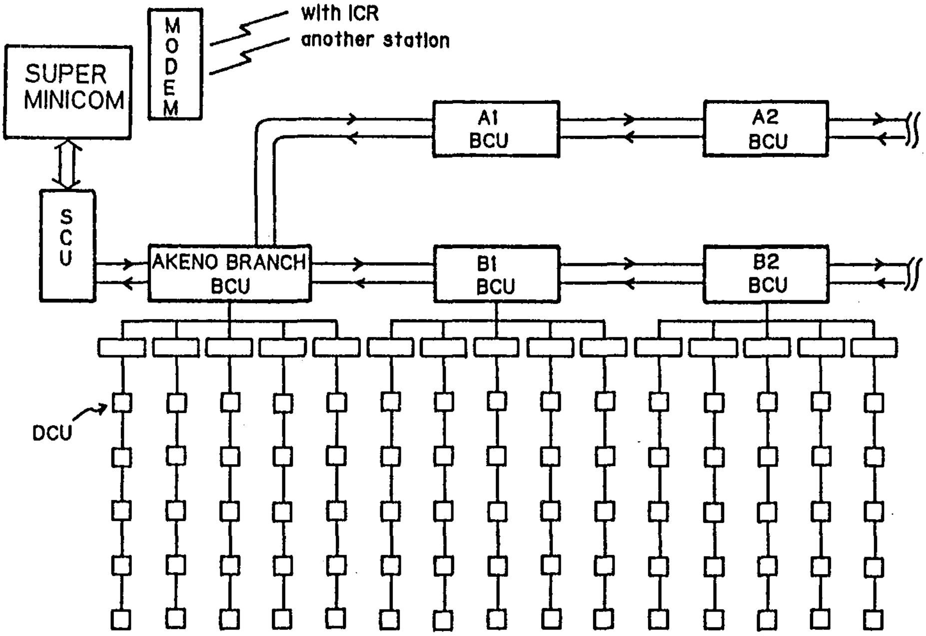


Fig.4 The data acquisition system of future surface array.

Acknowledgements

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