# Wide Area Small Air Shower Detection System Linked by Internet

T. Hamaguchi,[1] Y.S. Honda,[2] M. Katsumata,[1], E. Nakano,[1] Y. Saito,[3] Y. Sasaki,[4] T. Takahashi,[1], and Y. Teramoto[1]

*(1) Institute for Cosmic Ray Physics, Osaka City University, Osaka 558-8585, Japan*

*(2) Department of Electrical and Information Engineering, Kinki University Technical College, Mie 519-4395, Japan*

*(3) Osaka Science Museum, Osaka 530-0005, Japan*

*(4) Izumiootsu High School, Osaka 595-0012, Japan*

## Abstract

Development of an air shower detection system, consisting of widely distributed observational sites which are connected through the Internet, is described. The obtained data at each site are exchanged in (quasi) real time. For science educational purposes, sites are set up at museums and schools. The system is intended to detect time-correlated air showers arriving over a wide area.

## 1. Introduction

Possible existences of time correlated cosmic rays were first reported by Carrel and Martin [1] and by Kitamura et al. [2]. Carrel and Martin observed enhancements of simultaneous air showers measured by the detectors at four locations with several hundreds kilometers from each other. Kitamura et al. found ten events with chaotic behavior in the arrival time series of air showers. Those events were simultaneously observed by the two detection stations in the Kinki University campus during the 3.36 years. Of the ten events, five are coincident with the chaotic events observed at the Mitsuishi Observatory of Osaka City University which locates 115 km apart.

After those pioneering works, a network of detector: the North American Large Area Time Coincidence Array (NALTA) has been built and is now being operated [3,4,5] in the United States and Canada to search for time correlated events and highest energy cosmic rays. In Europe, before the large LEP detectors were closed, studies had been done by the ALEPH and L3 detectors with an extended air shower array [6,7].

Our project was started with the similar motivation. The system consists of standardized detector stations. Each station has four scintillation counters and it can locally reconstruct air showers. These stations exchange data in (quasi)

pp. 785–788 

real time through the Internet. This makes the system suitable for displaying the arriving cosmic rays over a wide area at the museums and schools.

## 2. Detector

One station consists of four scintillation counters, a data acquisition box (DA box) that has all the electronics for the station, a Windows PC, and a Global Positioning System (GPS) antenna, as shown in Fig. 1. Each counter is comprised of a pyramid-shaped vessel containing $70 \times 70 \times 4$ cm$^2$ plastic scintillator at the bottom and a Hamamatsu H6410 2" Photo-Multiplier Tube (PMT) at the top. The counters are typically placed on the roof of the building at the square corners of an approximately $10 \times 10$ m$^2$. The DA box has four channels of ADCs and TDCs, each having 12-bit resolution, as shown in Fig. 2. Triggers are made of coincidences of hits in three out of four counters. The system can measure the trigger time with an accuracy of 1 $\mu$s.

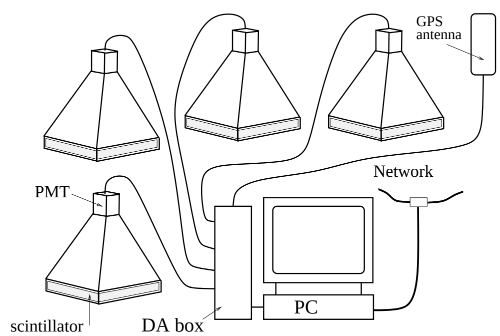


**Fig. 1.** One detector station.

The online software consists of two processes: a data acquisition process and a display process. The display process can show event displays, histograms, rate displays and a set of descriptions of cosmic rays. The code is written in Microsoft Visual C++6.0 to run on a Windows 2000 PC.

Data exchange between the stations is done by a Hyper Text Transport Protocol (HTTP) server. The reason for using HTTP is to pass the firewall of the site. Our system can transfer the data even when an HTTP proxy is the only one route of the site to the outside. The station periodically polls the HTTP server (currently in every two seconds). This enables us to distribute all the data to each site in the "quasi-real" time. Each data has unique station ID, run number, event number, site location data, GPS time and the ADC and TDC data. Since the link is a one-time connection, each station can start or stop at any time without disturbing the entire observation network.

Analysis programs, which run in a Linux PC, use the same protocol to receive the data from the server.

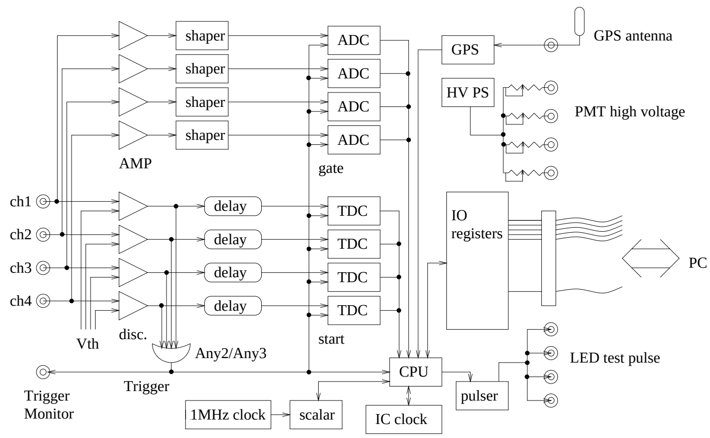


**Fig. 2.** Schematic of the electronics circuit.

## 3. Operation and Performance

The system has been operated with Osaka City University and Osaka Science Museum since 2000. Two more stations were added in 2002 at the Izumiootsu High School and Kinki University Technical College. Fig. 3 shows an example of the observed event rates during a 10-day period at three stations: Osaka City University, Osaka Science Museum and Izumiootsu High School. Correlations are seen on the rates at the three sites, which locate approximately 15 km apart.

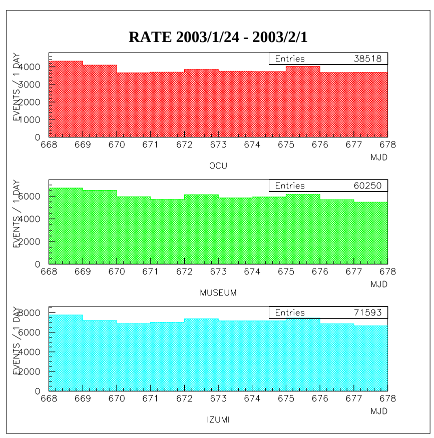


**Fig. 3.** An example of the measured event rates at three stations: Osaka City University, Osaka Science Museum and Izumiootsu High School.

From the analysis of the obtained data for one month period, the arrival time distribution showed exponential form which indicates that the system has no measuring bias to the arrival time. The trigger rate was approximately three per minute. To obtain the incident angle resolution, we fitted the shower front arrival time assuming the front is a plane. From the residuals of the fits, the angle resolution was derived to be 8°.

## 4. Summary

We have developed a cosmic ray air shower detection system suitable for detecting events arriving over a wide area with correlated time. The system consists of standardized detector stations connected through the Internet using HTTP. Each station is comprised of four scintillation counters with an electronics box and a PC, which locally reconstructs the air showers. The system is currently operating with four sites. A typical trigger rate at each station is three per minute. The arrival direction resolution is 8°. We plan to expand the system to cover a larger area. We are also working on reducing the cost of one station.

## 5. Acknowledgements

We thank Prof. T. Kitamura and W. Unno of Kinki University for encouraging us to build this system. We also thank H. Fujii of the National Laboratory for High Energy Physics (KEK) for the useful discussions in developing the software. We are also grateful to Prof. T. Sumiyoshi of Tokyo Metropolitan University and Dr. H. Okabe of Osaka Prefectual Education Center. This project is partially funded by a Grand-in-Aid for Science Research on Priority Areas by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT).

## 6. References

1. Carrel O., Martin M. 1994, Phys. Lett. B325, 526
2. Kitamura T. et al. 1997, Astroparticle Phys. 6, 279
3. Kumagai J. 1998, Physics Today, Oct., p.73
4. Snow G. "High Schools Join the Search for Most Energetic Particles in the Universe," 2002, Fermi News, Feb. 1, p.8
5. NALTA: http://crs.phys.ualberta.ca/nalta/
6. "Looking at cosmic rays with accelerator detectors," "ALEPH experiments go cosmic," "L3+C=new tool set to study cosmic-ray muons," 1999, CERN courier, Oct., p.29-33
7. B. Besier et al., 2000, Nucl. Instr. & Meth. A454, 201