The status and future prospect of the LAAS project

Nobuaki Ochi,[1] Atsushi Iyono,[2] Takeharu Konishi,[3] Toru Nakamura,[4] Takao Nakatsuka,[5] Soji Ohara,[6] Nobuharu Ohmori,[4] Kazuhide Okei,[7] Katsuhiko Saitoh,[8] Junpei Tada,[7] Nobusuke Takahashi,[9] Shuhei Tsuji,[10] Tomonori Wada,[7] Isao Yamamoto,[11] Yoshihiko Yamashita,[7] and the Large Area Air Shower (LAAS) group

(1) Simulation Science Center, Okayama Univ. of Science, Okayama 700-0005, Japan
(2) Dept. of Computer Simulation, Okayama Univ. of Science, Okayama 700-0005, Japan
(3) Dept. of Physics, Kinki Univ., Higashi-Osaka 577-8502, Japan
(4) Fac. of Science, Kochi Univ., Kochi 780-8520, Japan
(5) Okayama Shoka Univ., Okayama 700-8601, Japan
(6) Fac. of Economy, Nara Univ. of Industry, Ikomagun 636-0821, Japan
(7) Dept. of Physics, Okayama Univ., Okayama 700-8530, Japan
(8) Ashikaga Institute of Technology, Ashikaga 326-8558, Japan
(9) Dept. of Electronic and Information System Engineering, Hirosaki Univ., Hirosaki 036-8561, Japan
(10) Dept. of Information Sciences, Kawasaki Medical School, Kurashiki 701-0192, Japan
(11) Dept. of Information and Computer Engineering, Okayama Univ. of Science, Okayama 700-0005, Japan

Abstract

The Large Area Air Shower (LAAS) group was established in 1996 under a unique conception of cosmic ray observation in Japan. The LAAS group has been performing a network observation of EAS using 9 independent scintillator arrays scattered over a very large area. Two more arrays, one of which is at Norikura Observatory (2770m a.s.l.), are planned to be constructed in the near future. They utilize GPS receivers (1μs accuracy) for getting time stamps of EAS arrivals and the observational data are recorded under a standardized format. Thus we can handle all datasets from the LAAS arrays easily and homogeneously as if they were from a gigantic EAS detector system. The subjects we are studying by this project include large-scale correlations in EAS, GRB-like sporadic phenomena, EHE cosmic rays around 10^{18} eV and large-scale atmospheric dynamics. The current status and future prospects of the LAAS project are presented here.

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1. Introduction

The Large Area Air Shower (LAAS) group has been performing a network observation of EAS using 11 compact scintillation counter arrays (stations) scattered over a large part of Japan [4, 6]. The detectors are uniformly adjusted and absolute time stamps of EAS triggers are available from GPS receivers equipped at each station. By combining EAS data collected simultaneously at multiple stations, we can investigate various aspects of UHE cosmic rays. The subjects we are studying by this experiment include large-scale correlations in EAS, GRB-like sporadic phenomena, EHE cosmic rays around 10^{18} eV and large-scale atmospheric dynamics [2, 5, 6]. Simulation works using the CORSIKA code are also in progress [1].

2. The LAAS Project

Fig. 1. shows the schematic map of the LAAS stations. Geographical positions of them are listed in Table 1. Mutual distances between them are more than 10km except several station-combinations. Some profiles of the stations are shown in Table 2. Each station has 4–12 scintillation counters, as well as the GPS receiver. Trigger conditions are different station-by-station; 2- to 8-fold coincidences are applied, yielding the trigger rates of 300–21000 /24h. The counter arrangement and the trigger condition of the OU, OUS1 and OUS2 arrays were modified a few times. By operating these stations simultaneously, the whole system can be regarded as a gigantic EAS detector, say, a *cosmic ray interferometer*. As an example, the counter arrangement of the OUS2-c array is shown in Fig. 2. Computed by the CORSIKA code, the angular accuracy of the arrays is about 7 degrees and the mean energy of detected EAS is around 1 PeV.

As of April 2003, nine arrays are in operation, while NO and KCU arrays are under construction. The NO array is expected to bring new prospects to the LAAS project thanks to its high altitude of 2770m a.s.l. A more detailed description on the LAAS project can be found in [4, 6].

3. The LAAS/ARPEGIO Experiment

Among the LAAS stations, four stations in Okayama area (OU, OUS1, OUS2 and OUS3) are named the LAAS/ARPEGIO (Local Area Air Shower And Radio Pulse Echo Gazing Instruments at Okayama) experiment [4]. These arrays have different aspects from other stations: (i) 2-fold coincidence between counters separated by only 80cm has been applied for trigger condition since May 2002, (ii) mutual distances are relatively small; $\sim$100m within OUS and $\sim$1.1km between OU–OUS. For (i), the trigger rates are 30–70 times higher than those of other stations, i.e., lower energy threshold is achieved. For (ii), we can expect

Fig. 1. The schematic map of the LAAS stations.

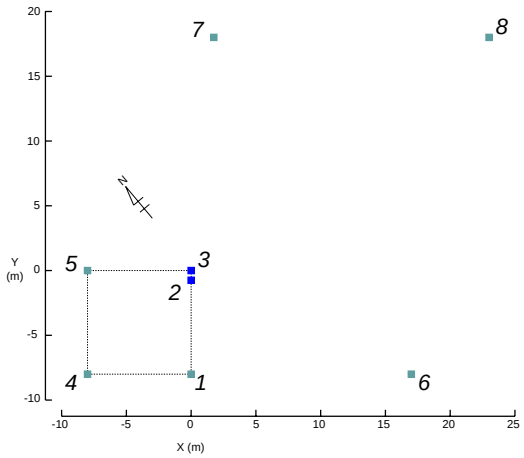

Fig. 2. The counter arrangement of the OUS2-c array.

the detection of higher energy EAS as coincident triggers among two or more stations. From observational data, we have already confirmed the detection of such events [7]. According to preliminary simulations, coincident events within OUS imply $\sim 10^{15.6}$eV of primary energy and coincident events between OU and OUS imply $\sim 10^{18}$eV [1]. Thus, by counting the number of coincident triggers between various array-combinations, we can calculate the energy spectrum of primary cosmic rays. In addition, the improvement of angular accuracy can be expected by combining timing data from multiple arrays. On the other hand, the LAAS/ARPEGIO stations are equipped with Yagi antennas to detect radar echoes from air shower columns, which is described elsewhere [3]. We are planning to reinforce the LAAS/ARPEGIO experiment by installing two additional arrays; the OU2 array near the OU array and an array at Okayama Shoka Univ., ∼2km distant from the OU array.

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4. References

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Table 1. The Geographical Positions of LAAS Stations.

Station name	Abbrev.	Lat. (N)	Long. (E)	Alt. (m)
Ashikaga Institute of Technology	AIT	36° 21′	139° 24′	49
Hirosaki University	HU	40° 35′	140° 29′	64
Kinki University 1	KU1	34° 39′	135° 36′	50
Kinki University 2	KU2	34° 39′	135° 36′	30
Kochi University	KCU	33° 33′	133° 29′	34
Nara University of Industry	NUI	34° 35′	135° 41′	130
Norikura Observatory	NO	36° 07′	137° 33′	2770
Okayama University	OU	34° 41′	133° 55′	30
Okayama University of Science 1	OUS1	34° 42′	133° 56′	63
Okayama University of Science 2	OUS2	34° 42′	133° 56′	81
Okayama University of Science 3	OUS3	34° 42′	133° 56′	65

Table 2. The Profiles of LAAS Stations.

	Number of counters		Trig. rate	
Station	Total	Trigger	(/24h)	Operation period
AIT	8	2	14000	11/01/2000 – now
HU	5	5	593	11/13/1998 – now
KU1	5	5	456	05/14/1993 – now
KU2	7	7	315	07/10/1998 – now
KCU	8	–	—	soon
NUI	7	7	449	07/10/1996 – now
NO	12	4	—	soon
OU-a	8	5	588	09/12/1996 – 12/22/1999
OU-az	8	3	1259	01/06/2000 – 03/30/2000
OU-b	8	3	1400	04/04/2000 – 05/13/2002
OU-c	8	2	15934	05/14/2002 – now
OUS1-a	4	4	763	09/02/1996 – 11/14/1997
OUS1-b	8	8	314	11/14/1997 – 01/04/1999
OUS1-c	8	4	730	01/05/1999 – 05/20/2002
OUS1-d	8	2	16493	05/21/2002 – now
OUS2-a	4	3	1522	04/23/2002 – 05/28/2002
OUS2-b	5	2	18536	05/29/2002 – 08/07/2002
OUS2-c	8	2	18178	08/07/2002 – now
OUS3	5	2	21088	12/29/2002 – now