Search for non-random features in arrival time series of air showers observed at Mt.Chacaltaya

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Abstract

Using arrival time series of air showers observed at Mt. Chacaltaya during 1991–1995, we have performed a time series analysis to search for non-random features of UHE cosmic rays. The location of the Chacaltaya air shower array (5200m a.s.l. and in the Southern hemisphere) is expected to reveal new aspects of UHE cosmic rays which cannot be observed by Northern, sea-level detectors. The arrival time structure of air showers is carefully examined in method of the cluster analysis. In this analysis, we count the number of air showers (N) observed within short time windows and compare the N distribution with the Poisson/Gaussian distribution. The discrepancy between the distributions possibly implies the existence of non-random components in UHE cosmic rays. From the Chacaltaya data, we picked up one cluster event, consisting of 182 EAS within 10min., though the significance was not enough. The arrival direction of the event was consistent with the Galactic plane, possibly implying the existence of sporadic UHE γ-ray emission from it.

1. Introduction

Sporadic non-random components of UHE cosmic rays from diffuse sources have been studied using arrival time series of air showers in this paper. Non-random features in arrival time series of air showers have been reported by some

pp. 195–198

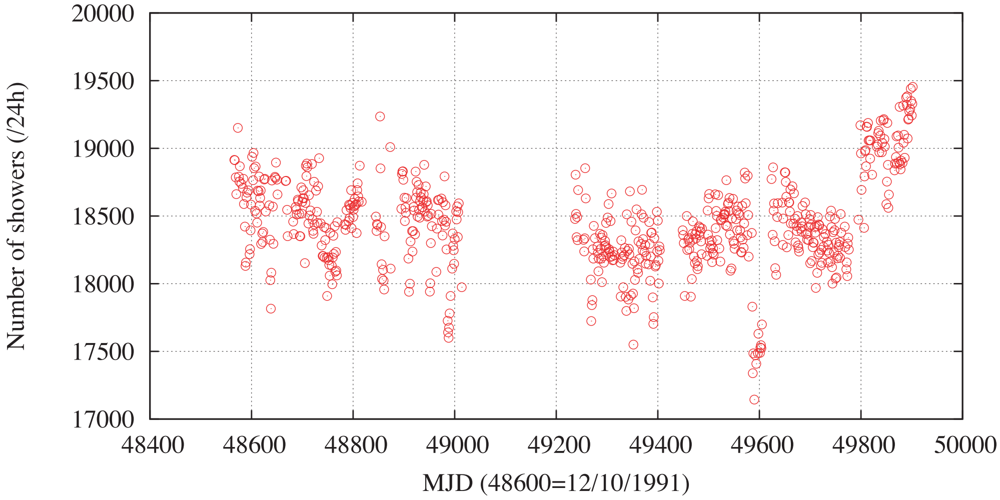

Fig. 1. The variation of Chacaltaya EAS rates. (zenith angle$\leq 30^\circ$)

observation groups. Katayose *et al.* reported the detection of 'clustered events', which consist of many air shower arrivals within short time intervals, and the concentration of their arrival directions at the Galactic plane [2]. Konishi *et al.* performed a similar analysis and also found an indication of the Galactic plane origin of their 'successive air shower events' [4]. They interpreted it as a consequence of flux of UHE γ-rays from the Galactic plane. The author also studied the subject using EAS data from the LAAS group and confirmed their results [5, 6].

In this report we apply the cluster analysis method to EAS data taken at Mt. Chacaltaya. Because the Chacaltaya detector is sensitive to lower energy air showers owing to the high altitude of 5200m a.s.l., it is expected that the above feature can be seen more clearly in the Chacaltaya data.

2. Experiment and Data

EAS data used in this report were collected by a scintillation counter array at Mt. Chacaltaya (Bolivia, $16^\circ 21'$ S, $68^\circ 08'$ W, 5200m a.s.l., 540g/cm^2 of atmospheric depth) during 1991–1995. The array consists of 40 counters for density measurement and 13 counters for FT measurement [1]. The trigger condition corresponds to the EAS size threshold of $\sim 10^4$ [3]. Only EAS data collected on the days when the array was properly working for 24 hours were employed. Under the shower restriction of the reconstructed zenith angle $\leq 30^\circ$, the average rate of 12.8 showers/min. and the total number of 1.17×10^7 showers were used in this analysis (Fig. 1.).

3. Analyses and Results

In the cluster analysis, we count the number of air showers (N) detected within a (fixed) short time window. No directional binning is applied. After that, the N distribution is compared with the Poisson/Gaussian distribution and the discrepancy between them possibly implies the existence of sporadic non-random components in UHE cosmic rays. As one can see in Fig. 1., the EAS trigger rate involves the long-term fluctuation, which can distort the shape of the N distribution. Thus we normalize each N by dividing by the ratio f_{day}/f_{ave}, where f_{day} is the trigger rate of the day and f_{ave} is the trigger rate of the whole data period (the time windows for N-counting are much shorter than day).

Three widths of the time windows, 1min., 10min. and 60min. are applied. The comparison of the N distribution with the Poisson/Gaussian distribution is shown in Fig. 2. In all figures, the good agreement is obtained. However, we notice the largest-N event in the figure of time window of 10min. The event stands in the outskirts of the distribution and consists of 182 showers (normalized $N = 182.86$), for which the expected frequency is 0.053. The arrival directions of EAS in the 'cluster event' are plotted in equatorial coordinates as Fig. 3. and they are consistent with the direction of the Galactic plane.

4. Discussion and Conclusion

We picked up one cluster event, which consists of 182 showers within 10min., though the significance was not enough. The arrival directions of EAS in the event (Fig. 3.) were distributed uniformly in the visible sky, but there is a possibility that some EAS were from the Galactic plane (or the Galactic center) and contributed to the cluster event. As another possibility for the event, we inquired in the GRB catalogues by BATSE [7] and IPN3 [8], but no GRB was observed on the date (Apr/08/1994, MJD=49450). To find out cluster events more effectively, an improvement of the analytical procedure is in progress.

5. References

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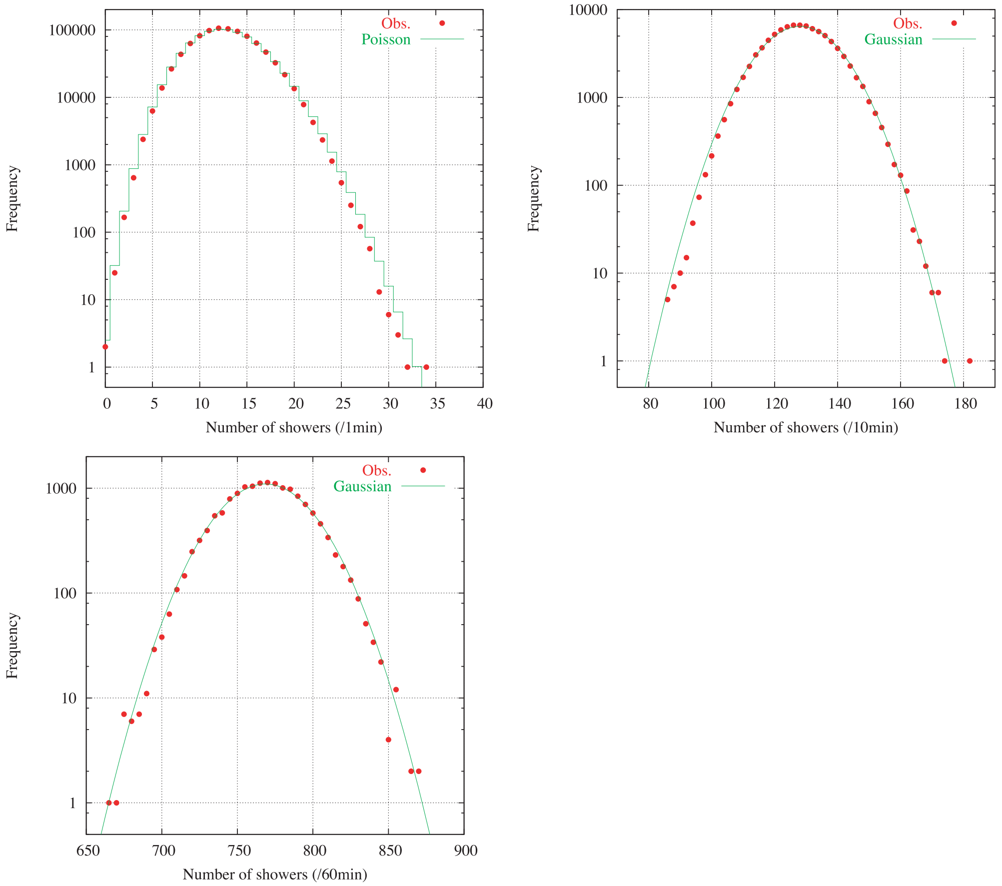

Fig. 2. The N distribution for time window of 1min. (top left), 10min. (top right) and 60min. (bottom).

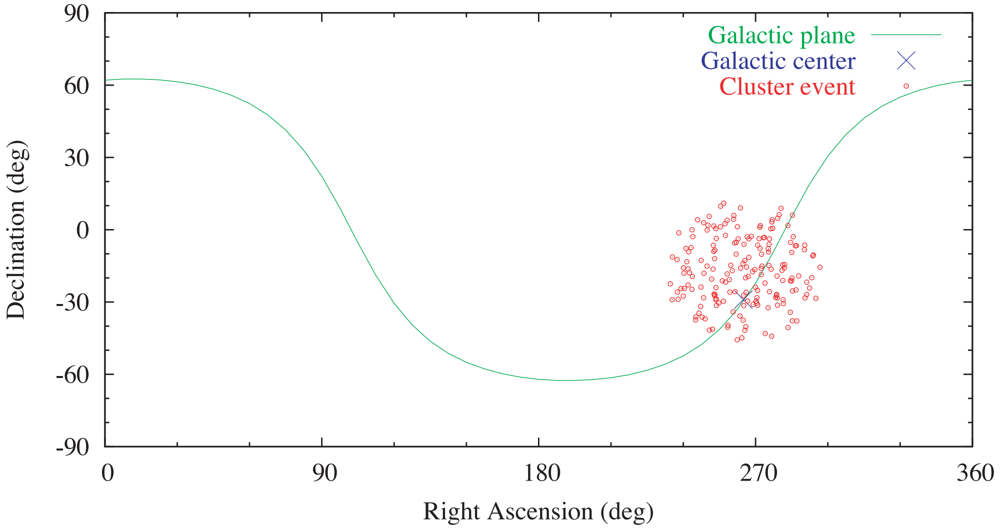

Fig. 3. The arrival directions of EAS in the ‘cluster event’.