Analysis of the arrival time of serial air showers by using Erlang Distribution and Poisson Distributon

Hiroyuki Takada,[1] N.Takahashi,[2] S.Kawaguchi[2]
(1) Graduate school of Science and Technology, Hirosaki University, Hirosaki 036-8561, Japan
(2) Faculty of Science and Technology, Hirosaki University, Hirosaki 036-8561, Japan

Abstract

We analyze arrival time of air shower using Hirosaki AS Array. This array consists of 5 scintillation detectors with GPS antenna for arrival times. We use two analysis methods. One is that the number of air showers observed within short time windows is analized by using Poisson distribution. The other is that the arrival time difference of k-events serial air showers by using Erlang distribution. We report the results of analysis by these two algorithm.

1. Introduction

We analyze arrival time of air shower using Hirosaki AS Array which consists of five scintillation detectors and GPS (Location:4035' N, 14028' E, 63m from sea level)[1]. By using the GPS, we can record arrival times of air showers with an accuracy of 1 micro second. A 5-fold coincidence within 140 nano seconds is used on the trigger condition for air shower events. The event rate is 0.412±0.028 events/min. Some special successive air shower events are recorded in short term among observation data which we will be explained later. Recently, N.Ochi et al. group [2] and T.Konishi et al. group [3] reported that the arrival time of direction of such the successive air showers tends to concentrate to the Galactic plane. Relating to their reports we analyzed similar problemes by two algorithm. One is with Poisson distribution and the other is with Erlang distribution. The comparison of both analysis is made in the later section. The period from January 1, 1999 to May 12, 2002 were selected for the analysis.

2. Analysis by using Poisson Distribution

In order to seek out a series of successive air shower events, first we count the number of detected air showers within a time window. By dividing the total observation time into some interval for example, 11 seconds (see later), we obtained frequency distribution or successive air shower events, counting the number

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of successive air shower events in the time interval. Usually, the frequency distribuitons agree with the Poisson distribution with their the average of observation. This means that cosmic rays arrive at Earth at random. However, acutually a discrepancies between them are found. The discrepancies occured in the range where the number of air shower is largest. Following two parameters are required to analyze the characteristic of successive air shower events. One is the time window and the other is the start point of analysis in time. Following figures show the frequency distributions (Fig.1 to Fig.4). We analyzed physical events, by shifting the start point with constant time window of 11 sec. We found the significant difference between observation from Poisson distribution in the range where number of air shower is largest (in Fig.3).

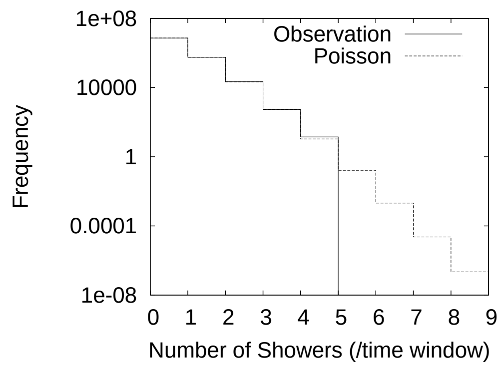

Fig. 1.

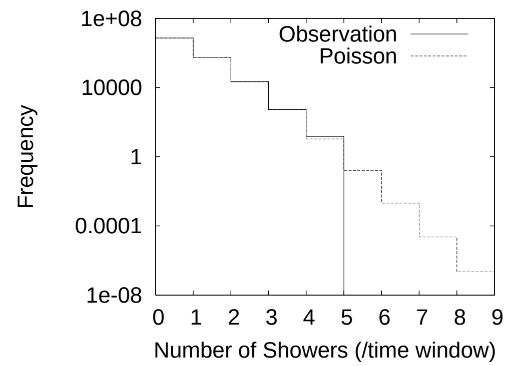

Fig. 2.

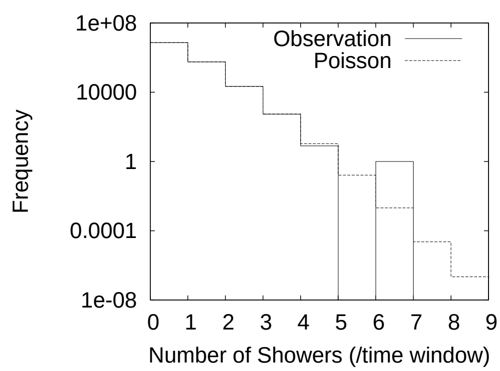

Fig. 3.

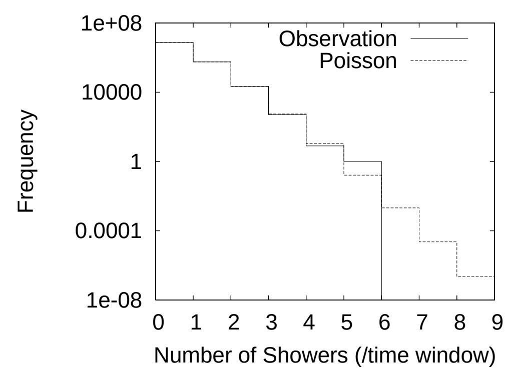

Fig. 4.

3. Analysis by using Erlang Distribution

Let us explain, how to utilize the Erlang distribution for extarcting the peculiar feature of successive air shower events. Here we sample successive air shower events, for example, six events. We take the time difference of No.1 event to No.6 event as first sample, that of No.2 to No.7 as the second, that of No.3 to No.8 as the third and so on. From these samples, we obtain frequency distributons of successive air shower events. In Fig.5, we compare observation with Erlang distribution and found significant difference between observation and the expected from Erlang distribution. We found significant discrepancy in smaller time difference, as shower in Fig.5.

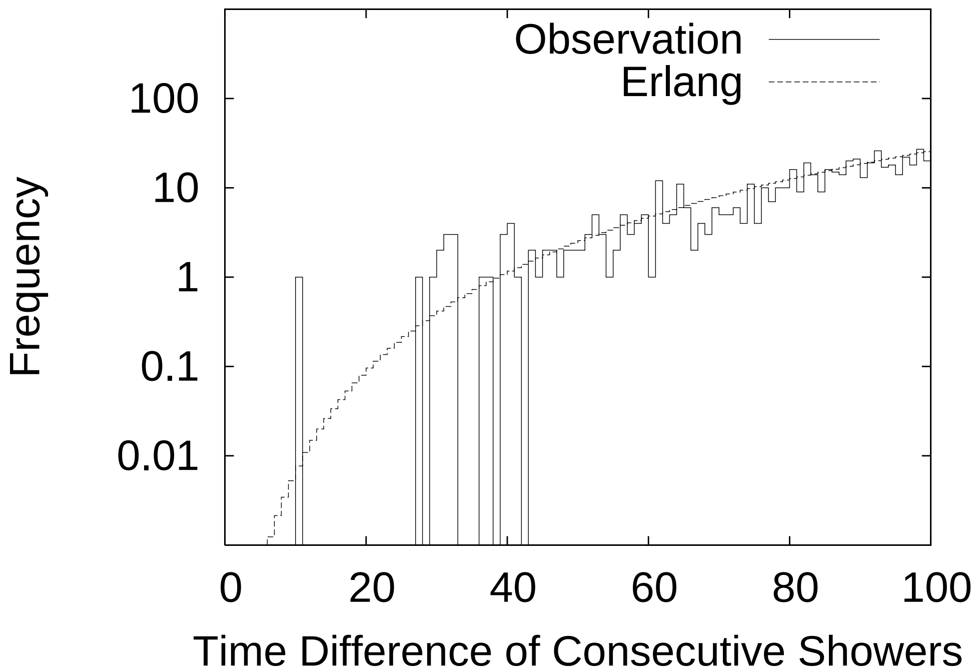

Fig. 5. The frequency distribution and Erlang distribution

4. Analysis and Comparison

Which is better method for the analysis of successive air shower events, if they are really ejected in short time interval from same astronomical object, the method based on Poisson distribution or that on Erlang distribution ? In our opinion, Erlang method is much better than Poisson method. The reason as follows: First, suppose that five successive air shower events is ejected in short time interval from the same object. Erlang method provides some characteristics over such a group which consist of five showers, while Poisson distribution may smear out such characteristics, because for example there may the possibility that two of five belong to one time interval and three of five belong to next time interval so that there are no correlation between the two and the three. The second, there are two parameters by which one analyze the events concerned, with constant time interval and searching of the total time interval in the case of Poisson distribution, while there is only one parameter, the time difference between successive air shower events.

5. Conclusions

Comparing the data analysis by Poisson distribution procedure with that by Erlang distribution procedure, it is concluded that we could get the candidates for sccessive air shower events without missing them, if we utilize Erlang distribution method.

6. References

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