Development of the Stereoscopic Data Acquisition System of the CANGAROO-III Telescope

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Abstract

We report the development of the data acquisition (DAQ) system of the CANGAROO-III stereoscopic imaging Cherenkov telescope. Each DAQ system of two 10m telescopes is triggered by shower events individually. The trigger pulse and the event number are transmitted between telescopes, and the differences of the arrival times of triggers from two telescopes are measured. With this information the stereoscopic shower events are reconstructed in the off-line analysis. The stereoscopic events are detected at a rate of a few Hz, which shows that the energy

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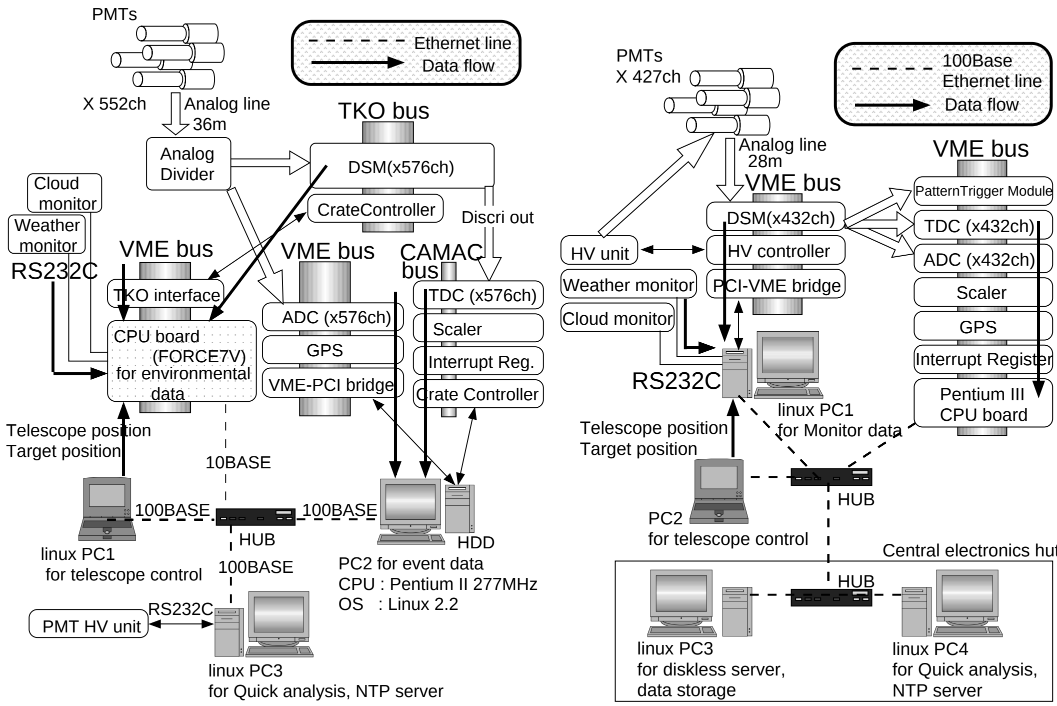

Fig. 1. Overview of the data acquisition system of the first telescope (left) and the second telescope (right)

threshold of stereoscopic observations depends on that of the first telescope.

1. Introduction

The CANGAROO-III project to construct an array of four 10 m imaging atmospheric Cherenkov telescopes is underway in Woomera, South Australia [1]. Stereoscopic observations with two telescopes have started in Dec. 2002. Here we describe the stereoscopic data acquisition system in detail.

2. Data acquisition system of the first and second telescopes

An overview of the DAQ system of the first (T1) and second (T2) telescopes is shown in Fig. 1. The biggest difference of the DAQ system between the first and second telescopes is the kind of data-bus. The read-transfer speeds of both CAMAC and TKO data-buses are at most 1 Mbyte/sec, while that of the VME (VME32 type) is $\sim$8 Mbytes/sec. Thus the readout of second telescope's DAQ system, which consists of only VME modules, is faster than that of the first telescope. The first and second telescopes have multi-pixel cameras which consist of 552 and 427 PMTs [2, 4]. The signal from each PMT is transmitted through a twisted cable to the electronics hut, and divided to both a custom-made VME9U-bus 32ch 12(T1)/15(T2)bit charge sensitive ADC and a custom-made TKO(T1)/VME9U(T2)-bus Discriminator & Summing amplifier Module (hereafter DSM)[3].

In the DSM, the signal from each PMT is amplified with a shaping amplifier, and the signals of 16 channels are summed (hereafter ASUM). The amplified signal is fed to two discriminators; one is for measurement of the trigger time by a TDC with a 0.8 ns resolution, while the other is for measurement of the counts over the threshold level during about 1 ms. Both act to monitor and reduce the night sky background; the former based on the fact that the telescope is parabolic and the time propagation of a shower can be reproduced with an accuracy of less than 1 ns, and the latter is used to reject PMTs hit by starlight in the off-line analysis. The thresholds of both discriminators are adjustable via the data-bus. A pulse with a voltage proportional to the number of PMTs hit at same time is generated (hereafter LSUM).

The DAQ trigger is generated as follows. LSUM signals from DSMs are summed, and discriminated to determine the number of PMTs hit within ∼20ns. The threshold of the discriminator is set to be 4 or 5 PMTs. On the other hand, the ASUM signal is discriminated to select a concentrated hit pattern. PMT triggers are generated from the coincidence of the outputs from the two discriminators, and then DAQ triggers are generated. Furthermore in order to lower the energy threshold, a module with CPLDs, which selects hit pattern in hardware whether triggered PMTs are adjacent or not, has been installed to the second telescope and under test [5]. The DAQ trigger promptly opens an ADC gate of between 50 and 100 ns width, which converts the amplified signal from the DSM after a 150 ns delay provided by a delay-line chip onboard the ADC. The DAQ trigger also latches the time of the VME-bus GPS receiver.

A PC(T1)/VME-bus CPU board(T2) collects data from the ADCs, TDCs and the GPS. The PC runs a linux operating system, and a portable DAQ system is installed for collecting and storing all data on a hard-disk. The total size of the data recorded in an event is 1.5 kbytes. The DAQ system can accept triggers at a rate of 80(T1)/350(T2) Hz with a dead time of 20% as shown in Fig. 2.

3. Stereoscopic data acquisition system

Stereoscopic observations with two 10 m telescopes have started in Dec. 2002. In the stereoscopic observations the coincidence of DAQ triggers from two telescopes is not required, and the DAQ system of each telescope records the data by a trigger generated in each telescope. For reconstructing shower events in the off-line analysis, both the trigger pulse and the lower 16 bit event number of the first telescope are transmitted through 150 m optical fibers to the DAQ system of the second telescope, and the differences of the arrival times of triggers

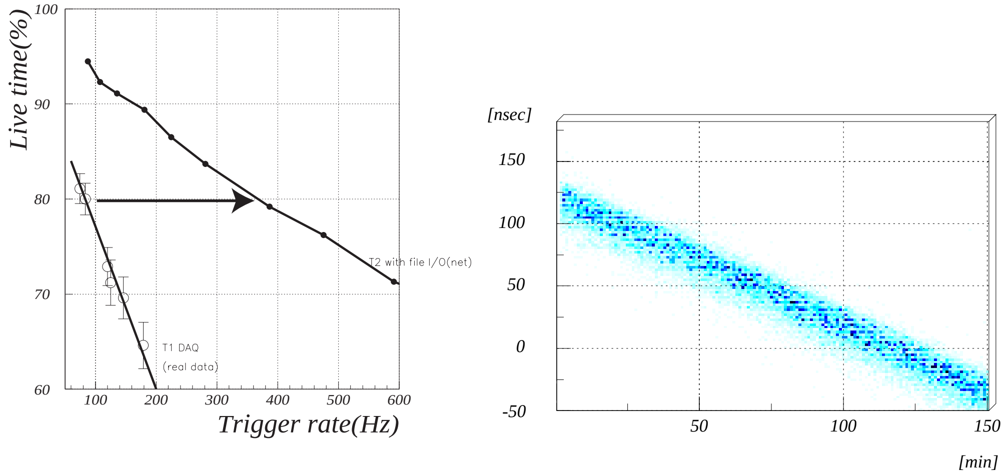

Fig. 2. (Left)Measured live time of the DAQ system. (Right)Measured difference of the arrival times of triggers from two telescopes.

from two telescopes are measured with 1ns resolution by the DAQ system of the second telescope. The measured difference is shown in Fig. 2, and coincident with difference of the light path between telescopes.

In typical observations the trigger rate of the first telescope is 20 Hz, and the rate of shower events is 2 Hz after reduction of the night sky background. On the other hand the rate of shower events taken with the second telescope is more than 30 Hz because the performace of the mirror and the camera system were greatly improved [2, 6]. Stereoscopic shower events are reconstructed in the off-line analysis and detected at a rate of 2 Hz. An example of reconstructed image is shown in the reference [1]. At present the energy threshold of the stereoscopic observations depends on that of the first telescope, which is higher than the second telescope by factor 3 or more. But the stereoscopic energy threshold will lower in observations with the second and third/fourth telescopes, which are to be completed at the end of 2003.

4. References

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